THE EFFECT OF DIET ON URINARY SULFUR EXCRETION OF PRESCHOOL CHILDREN

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THE EFFECT OF DIET ON URINARY SULFUR EXCRETION

OF PRESCHOOL CHILDREN

by

GLADYS PAULINE BOND

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INTRODUCTION

This report on urinary sulfur excretion is part of a study done in an effort to add to our present knowledge of the mineral metabolism of preschool children. While sulfur is one of the inorganic ions essential to normal nutrition, few studies have been made to determine its functions. This lack of experimentation may be due to several factors. First, sulfur is found in the body in the form of complex organic compounds rather than an inorganic substance. The majority of these compounds are protein in nature and complicated in structure. Thus the determination of sulfur is not a simple procedure. Since sulfur is in combination with the protein and the amounts are quite nearly proportionate, it has been assumed that the body obtained sufficient sulfur if the diet contained adequate protein. Nevertheless, sulfur is a small but integral part of the living organism, as shown by Dr. H. B. Lewis' chart:(1)

Sulfur Compounds in the living organism

A. Naturally occurring organic sulfur compounds containing nitrogen
  1. Proteins (0.2 to 5.0 per cent S)
  2. Known constituents of the protein molecule - The sulfur-containing amino acids
     a. Cystine - Wollaston - 1810-Calculi - Morner 1899-protein
     b. Methionine - Mueller - 1923 - Barger and Coyne - 1928
  3. Probable derivatives of protein or of the above amino acids
     a. Taurine (taurochloric acid)
     b. Cysteine
     c. Ergothioneine
     d. Glutathione (reduced and oxidized)

e. Insulin
f. Mercapturic acids

B. Compounds related to or derivatives of naturally occurring sulfur compounds (the biological significance of these remains to be proven)
   1. Homologues of cystine or cysteine
      a. Homocystine (homocysteine)
      b. Pentocystine (pentocysteine)
   2. Homologues of methionine
      a. Homomethionine
   3. Thiolhistidine
   4. Products of partial oxidation of cystine and cysteine
      a. Cysteic acid
      b. Suboxidation products of cystine and cysteine.

(Toennies - Hammett)

Because it forms such an important part of all living tissue, the functions and requirements of sulfur should be studied in detail.

The urinary figures presented in the following pages represent one possibility for study——that of total sulfur elimination. Actually, these figures include fractions which could be determined separately. The larger amount of sulfur is eliminated in the inorganic sulfate sulfur fraction. The ethereal or conjugated sulfuric acids include a smaller portion of the oxidized sulfur while the sulfur compounds of organic nature constitute the remainder of the sulfur eliminated.

REVIEW OF LITERATURE

Since an adequate protein intake apparently insures an adequate sulfur intake, there have been few studies on sulfur metabolism. In fact, the literature up to the present time contains but one reference to a sulfur balance study done on preschool children, so there have been no recommendations as to dietary sulfur requirements. There have been several studies on infants as well as a few scattered reports on adults. Many of the adult studies have been made on hospital patients which makes it impossible for the results to be used in comparison with the normal subjects of this study. Many investigators have reported sulfur balance studies on animals. A full review of these latter studies will not be included in this paper, however mention shall be made only of those which might have some pertinence to this particular study.

All investigators seem agreed that the major portion of the sulfur is eliminated in the oxidized form through the kidneys. Shohl and Sato [2 & 3] studied two babies, 7 and 9 months old, and reported that 90% of the sulfur was eliminated through the kidneys. Blazso(1938)[4] found from a study of 7 infants aged 1-6 months, and 9 children 3-14 years, that in both groups the urinary sulfur exceeded the fecal excretion. Cooley, Penberthy, Armstrong, Hunscher, Macy, and Cope[5] found the average percentage urinary sulfur excretions of two girls (11 and 7½ years old) to be 76.43% and 76.26% respectively. These results were considerably lower than those presented by Shohl and Sato[2 & 3] for infants, but may merely indicate a higher fecal sulfur excretion by the older children.

Some comparative studies of the utilization of human and cow milk have been made on infants to determine if there are differences in sulfur metabolism. Blazsó[6] reported that the infants on his study retained approximately 90% of the sulfur from human milk, 75% from a diet of cow and human milk, and only 60% from a diet of cow milk alone. He also noted that boiling human milk reduced the sulfur retention 3-5%.[7]

It might be expected that the urinary and fecal sulfur excretions would vary between infants and children. Nevertheless, Blazsó[4] found that on the basis of body weight the fecal sulfur was of the same concentration in both groups. On the other hand, he found that the concentration of urinary sulfur was from four to six times as great in the children as in the infants.

Although all human studies are not directly comparable with this report, certain conditions have an effect on the sulfur metabolism. Coons, Coons, and Schiefelbusch[8] found a negative sulfur balance during pregnancy. And, conversely, Hummell, Sternberger, Hunscher, and Macy[9] reported a mean daily sulfur balance of 0.34 ± 0.13 gm. during the last 145 days of pregnancy. Hummell, Hunscher, Bates, Bonner, and Macy found a mean daily storage of 0.27 gms. of sulfur in another primapora observed during the last 65 days of gestation.

Since sulfur is so widely associated with protein, the relationship is commonly expressed as a N/S ratio. This ratio varied under different conditions of diet. Folin (1905)[11] found that the ratio for an adult man was practically the same on a high and low protein diet (11.5 and 11.8 respectively). In animal studies Terraine and Razafimahery (1935)[12] found that there was a sharp increase in the N/S ratio of the excreta of animals going from simple privation of proteins to complete starvation. As starvation continued, there was a slow diminution in the ratio and just before death a further decline although the total amounts of nitrogen and sulfur were much increased. They interpreted it as meaning that, in the last phase, muscle tissue and sulfur containing amino acids were undergoing disintegration. The quality of protein apparently had no influence on the N/S ratio in hogs since Rajzman (1936)[13] reported the ratio remained the same even when the diet contained poor or mediocre quality protein. This ratio may not be retained under all conditions, however.

The sulfur excretion is also affected by tissue injuries, operations, and certain diseases. Cuthbertson (1931)[14] reported an early catabolic loss of nitrogen and sulfur resulting from tissue injury--the increase in sulfur being due to a slightly greater proportionate increase in excretion of inorganic sulfate. The N/S ratio may also be altered in diseased conditions. Grabfield and Prescott[15] noted that in congestive heart failure, orthostatic albuminuria, toxemia of pregnancy and glomerulonephritis, the ratio is approximately 20:1. In the nephrosis syndrome, due to low sulfur, the ratio may go as high as 30:1.

The determining factor in the sulfur elimination of normal individuals apparently is the protein intake. Although Folin [11] reported the N/S ratio to be the same on a high or low protein diet, he found that the nitrogen and sulfur excretions were less on the low protein diet. The excreted sulfur fractions, however, did not vary in the same proportion from a high to low protein diet. The inorganic sulfate sulfur and conjugated sulfur were reduced on the low protein diet while the organic sulfur excretion was practically the same on both diets. In rabbits Razafimahery (1935)[16] found that the excretion of combined sulfur was slightly increased when a regime rich in protein replaced a non-protein one. Blazso[4] found that while the infants in his study retained only 40% of the protein nitrogen absorbed, they retained up to 90% of the protein sulfur absorbed. He concluded, therefore, that it is predominantly the sulfur containing constituents of the protein which are utilized by the growing organism.

Although these studies show general trends in sulfur metabolism of the living organism, human and animal, the data presented is too scattered and incomplete to be conclusive. There is a definite need for more detailed studies of sulfur metabolism.

EXPERIMENTAL PROCEDURE

This urinary sulfur study was one of a series of studies made to determine whether the addition of calories in different forms had any effect on the protein or mineral metabolism of a group of pre-school children. The six subjects, three boys and three girls, ranged in age from forty-two to fifty-seven months at the beginning of the study. All were in good physical condition as determined by complete medical examinations and by a thorough study of their past medical histories. The nutritional backgrounds of the children were similar inasmuch as four of them (Y, E, C, and MJ) had been in the same state institution* since birth, and the other two, J and K, had been together in a boarding home. All had had some of the usual childhood diseases, but in no instance had there been any irregularity which would indicate that any of the normal metabolic processes had been disturbed or impaired. Their height-weight records, as shown in Table 1 were within the normal range for children of the same height and age according to the standards set by Wood and Baldwin.[17]

The children lived for the entire three months' experimental period in one of the college houses located on the campus. Since any balance study necessitates the most carefully controlled conditions possible, they followed a definite daily routine in their activities, as presented in Table 2. They were together at all times, being segregated

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*Lapeer Home and Training School, Lapeer, Michigan.

TABLE 1

COMPARISON OF PHYSICAL MEASUREMENTS OF CHILDREN WITH BALDWIN-WOOD STANDARDS

			Baldwin-Wood			Baldwin-Wood	
Child	Age	Height	Average Height	Variation	Weight	Average Weight	Variation
	Months	cm.	cm.	%	kg.	kg.	%
C	47	103.3	102.51	+0.86	14.94	17.01	-1.22
	50	105.5	104.33	+1.12	17.23	17.42	-1.09
E	50	105.5	104.33	+1.12	17.38	17.42	-0.23
	53	107.0	105.98	+0.96	20.13	17.90	+1.25
K	42	102.6	98.88	+3.76	16.19	16.06	+0.81
	43	103.1	98.88	+4.27	16.51	16.06	+2.80
J	55	109.6	105.31	+4.07	16.87	17.18	-0.18
	58	111.95	107.23	+4.40	19.89	17.61	+1.29
MJ	51	103.4	103.10	+0.29	15.86	16.51	-0.39
	54	105.0	105.31	-0.29	17.63	17.18	+0.26
Y	57	101.1	107.23	-5.72	17.17	17.61	-2.50
	60	103.6	109.02	-4.97	21.03	17.95	+1.72

TABLE 2

DAILY ROUTINE OF CHILDREN

A. M.		P. M.	
Hour	Activity	Hour	Activity
6:30-7:00	Awakened, went to toilet, weighed and measured	1:00-3:30	Nap
7:00-7:30	Dressed	3:30-4:00	Toilet; dressed to play
7:30-8:15	Breakfast	4:00-5:00	Play
8:15-9:00	Toilet; prepared to go outdoors or other play activity	5:00-5:30	Toilet; bath; undressed
9:00-11:00	Play	5:30-6:15	Supper
11:00-11:45	Toilet; prepared for lunch	6:15-6:45	Play (Quiet)
11:45-12:30	Lunch	6:45-7:00	Toilet
12:30-1:00	Toilet; undressed for nap	7:00	Bed

only on two occasions, when a child had a slight cold. The same trained persons supervised their activities constantly, with the aim in view, however, of making this supervision as nonapparent as possible to the children. By employing the same supervision at all times, the investigators hoped to eliminate any possibility of emotional stimuli due to the presence of persons unacquainted with the children and general technique of the experiment. The children seemed happy and well adjusted throughout the study, with only an occasional emotion outbreak, which is the natural and normal reaction in a group of children.

The children ate four different diets, the only variable being additional calories in different forms. In order that the children might become adjusted to their new food and environment, there was a 14 day preliminary period. During this time they ate the same foods which were included in the first diet.

The first, or basal, diet continued for ten 3-day periods (numbers 1-10) and contained the foods listed in Table 3. This diet was

TABLE 3

DAILY BASAL DIET*

Food	Weight
	(gm)
Milk	800
Ralstons	20
Orange Juice	200
Beef	40
Peaches	150
Applesauce	150
Celery	20
Beans	100
Tomatoes	100
Potatoes	80
Butter	20
Sugar	20
Bread	60
Eggs	40
Water	800

*Diet fed to heaviest child E on basis of
95 cal. 1 kg. body wt.
3 g. prot. 1 kg. body wt.

calculated for the heaviest child, E, on the basis of 95 calories and 3 grams of protein per kilogram body weight. The other children received diets calculated as fractions of that fed to subject E, (Table 4). Thus each child received the same amount of food in reference to his weight; for example, each child drank the same amount of milk per kilogram. And since the childrens' weights varied, their diet factors were recalculated at the beginning of each new diet period.

TABLE 4

DIET FACTORS AS BASED ON INDIVIDUAL WEIGHTS*

Child	Basal	High Fat	High Starch	High Sugar
C	.84	.82	.82	.89
E	1.0	.95	.95	1.04
K	.91	-	-	-
J	.94	.94	-	-
MJ	.89	.87	-	-
Y	.95	.95	.95	1.06

*The diet factors were determined by the individual weights and were computed as fractions of the diet (1.0) fed to the heaviest child, E.

The second diet period continued for eight 3-day periods (numbers 11-18). During this time filtered butter fat was added to the basal diet daily, thereby introducing a calculated 20% increase in the caloric content of the diet. The butter was easily added to the vegetables and cereals, apparently escaping notice on the part of the children.

The third diet lasted for the next eight 3-day periods (numbers 19-26). The calculated 20% increase in caloric content over that of the basal diet was effected by the addition of cornstarch. Unlike the high fat diet, the high starch diet presented some difficulties as to a method of feeding cornstarch in a palatable form. Finally, since the children liked cake, the problem was solved by making the cornstarch into individual cakes. While these were not exactly like real cake, the children ate them with no serious objections.

The fourth and last diet also continued over eight 3-day periods (numbers 27-34). The calculated 20% increase in calories was made by adding sugar to the diet. This modification involved no difficulties whatsoever since the sugar was made into candy. The children were very pleased with the change in their diet and seemed more impressed by this than any of the other modifications.

Every precaution was taken to weigh and feed the diets quantitatively. The food was weighed in advance for three day periods from the same source of supply. Thus the three day food samples were identical in composition. Duplicate samples of the smallest child's daily intake (C) were saved and dried to constant weight for analysis. The children ate their diets quantitatively, which included wiping the dishes with small pieces of bread and rinsing them with distilled water. These washings were then added to the food for the same day. The distilled water intake was also measured for each child.*

Three of the children made no objection to any of their food throughout the entire experiment. One child, K, was taken off directly

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*The individual daily distilled water intake was as follows:

E - 800 gms.	K - 723 gms.
Y - 760 "	MJ - 707 "
J - 747 "	C - 697 "

following the basal diet because of his complete refusal to cooperate. And while the other two, J and MJ, remained on the study until the end, their excretion figures were not included on the high starch and high sugar diets because they did not eat all of their food in some instances. The difficulties incurred with these girls probably had a psychological rather an a physiological basis.

The procedure followed for the urinary sulfur analysis was the Denis[18] modification of the Benedict method.[19] 50 ml* of the three day pooled sample of urine were measured into an evaporating dish and 5 ml.** of the Benedict-Denis oxidizing agent added to it. Triplicate determinations were made on each sample. The samples were placed on an electric plate at low temperature and evaporated. Then the temperature was turned up through medium to high heat and left until the mixture was thoroughly charred. To insure complete oxidation, the evaporating dish and contents were placed in the muffle furnace at 750° for 20 minutes, removed, cooled, and 20 ml. of 10% HCl added to dissolve the oxidized mixture. This acid solution was then transferred quantitatively into a 250 ml. beaker with 100 ml. of distilled water. The contents of the beaker were heated to just below the boiling point, and 25 ml. of 10% $BaCl_2$ added slowly with constant stirring. This was then left on the steam bath for 18 hours or more, filtered through a

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*The Benedict-Denis method suggests 20 ml. of urine, but due to the dilution of some of the childrens' urine, 50 ml. of urine was used in this study. (In some instances, smaller amounts of urine were used due to nonavailability of larger samples.)

**Preliminary tests were run, using 5 and 10 ml. portions of the oxidizing reagent. Since there was no appreciable difference between results obtained from the varying amounts, the 5 ml. portion was used so that there would be less error in the form of additional Na ions introduced.

porous bottom crucible and the precipitate washed with hot distilled water. The crucible was next heated in the muffle furnace at 750° for 20 minutes, cooled, and weighed. The total sulfur figures were calculated from the weight of the $BaSO_4$ thus obtained.

Preliminary tests were run, using Na_2SO_4 and Na_2SO_4 plus urine. The average percentage recovery was 99.89%, and in no instance was there more than a 2.6% variation from the theoretical yield (Table 5).

TABLE 5

PRELIMINARY TESTS TO DETERMINE PERCENTAGE RECOVERY OF SULFUR AS $BaSO_4$

Theoretical Yield	Na_2SO_4	Urine + Na_2SO_4	Urine	% Recovery
.1002	.0985	--	--	98.2
.1002	.0978	--	--	97.6
.1002	--	.2161	.1185	97.4
.1002	--	.2183	--	99.6
.1002	.0985	--	--	98.2
.1002	.0991	--	--	98.9
.1002	--	.2079	.1056	102.1
.1002	--	.2082	--	102.4
.1125	.1132	--	--	100.6
.1125	.1142	--	--	101.5
.1125	--	.2307	.1158	102.1
.1125	--	.2284	--	100.1
			Average	99.89

PRESENTATION OF DATA

AND

DISCUSSION

The following data represents the urinary sulfur analyses for six preschool children on four different diets: (1) basal diet, (2) basal diet plus fat, (3) basal diet plus starch, (4) basal diet plus sugar. The entire study comprised thirty-four three day periods; the basal diet included the first ten periods and the modified diets eight periods each. The presentation of data follows the above order in which the children ate the diets, beginning with the basal diet.

Urinary Sulfur Excretion on Basal Diet

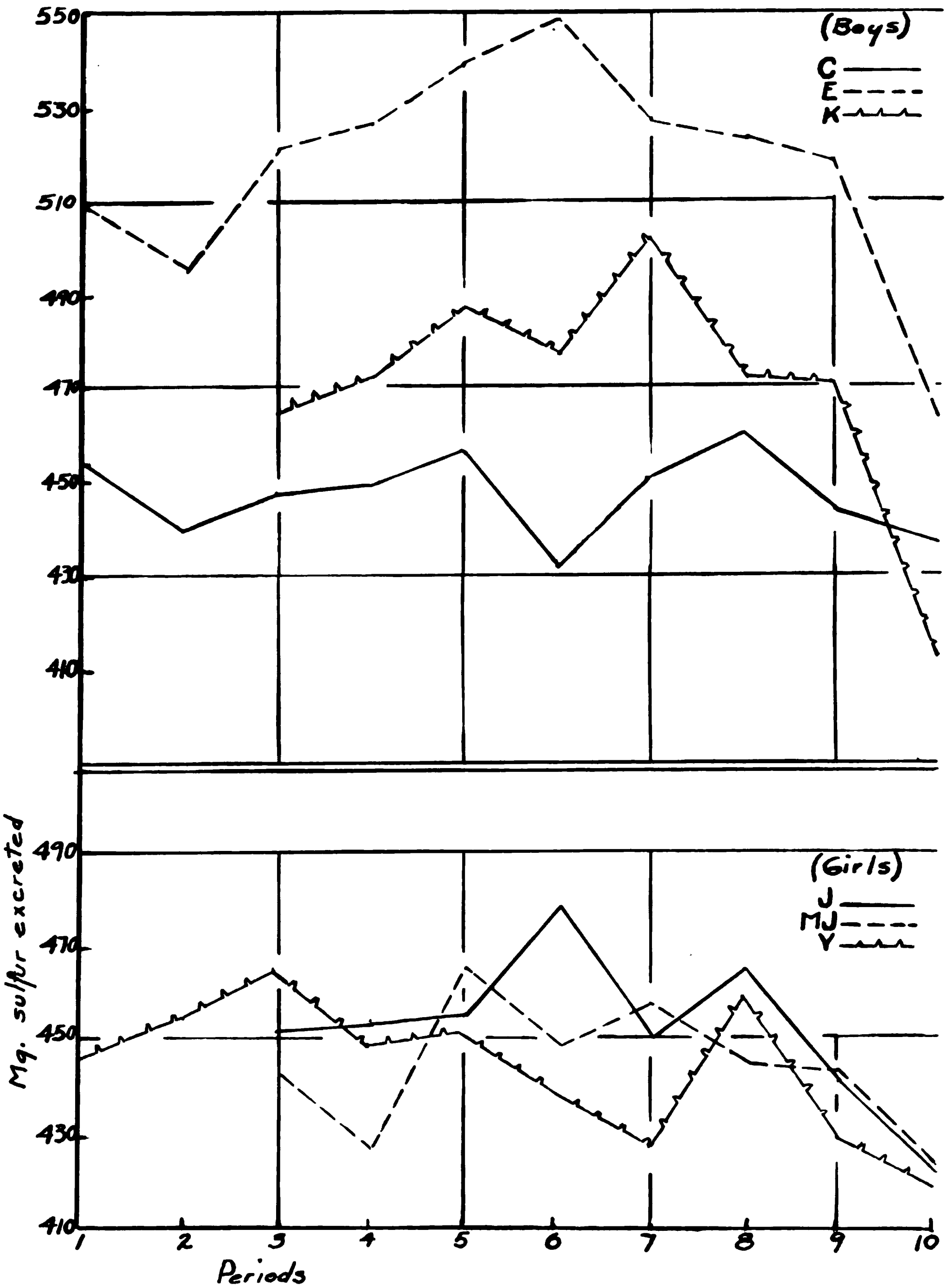
The average total sulfur excretions for the basal diet varied from 429 to 496 mg. (Table 6, Chart 1). The child E had the greatest average excretion (496.8 mg.) and also had the largest calculated intake (665 mg.). The child C excreted the smallest total amount of sulfur (429 mg.) and had the smallest intake (559 mg.).

Since each child received a constant diet, his sulfur intake should have been uniform throughout the basal diet. However, there were variations in the individual total sulfur excretions which would seem to indicate that the sulfur intakes were not constant from period to period (Table 6). Hawks, Dye, and Bray[20] have shown by actual analysis that the nitrogen content of supposedly constant diets varied to some degree.

Per.	Child	ight	Total Sulfur Intake	Excretion	Var. From Individual Average
		kg.)	(mg.)	[illegible]g.)	%
	C				
1		7.38	665.0	[illegible].0	-3.26
2		7.38	665.[illegible]	[illegible].3	-4.33
3		7.38	665.[illegible]	[illegible].7	+0.99
4		7.46	665.[illegible]	[illegible].5	+2.15
5		7.45	665.0	[illegible]8	[illegible]
6		7.46	665.0	[illegible]	[illegible]
7		7.47	665.0	[illegible]	[illegible]
8		7.47	665.0	[illegible]	[illegible]
9		[illegible].50	665.0	[illegible]	[illegible]
10		[illegible]	665.0	[illegible]	[illegible]
Av.		[illegible]	665.0	[illegible]	[illegible]
	MJ				
1		17.[illegible]	[illegible]	[illegible]	[illegible]
2		17.[illegible]	[illegible]	[illegible]	[illegible]
3		17.1[illegible]	[illegible]	[illegible]	[illegible]
4		17.30	[illegible]	[illegible]	[illegible]
5		17.33	[illegible]	[illegible]	[illegible]
6		17.36	[illegible]	[illegible]	[illegible]
7		17.42	[illegible]	[illegible]	[illegible]
8		17.29	6[illegible]	[illegible]	[illegible]
9		17.56	62[illegible]	[illegible]	[illegible]
10		17.57	63[illegible]	[illegible]	[illegible]
Av.		17.33	632.[illegible]	[illegible]	[illegible]

Chart 1.

TOTAL SULFUR EXCRETION ON BASAL DIET

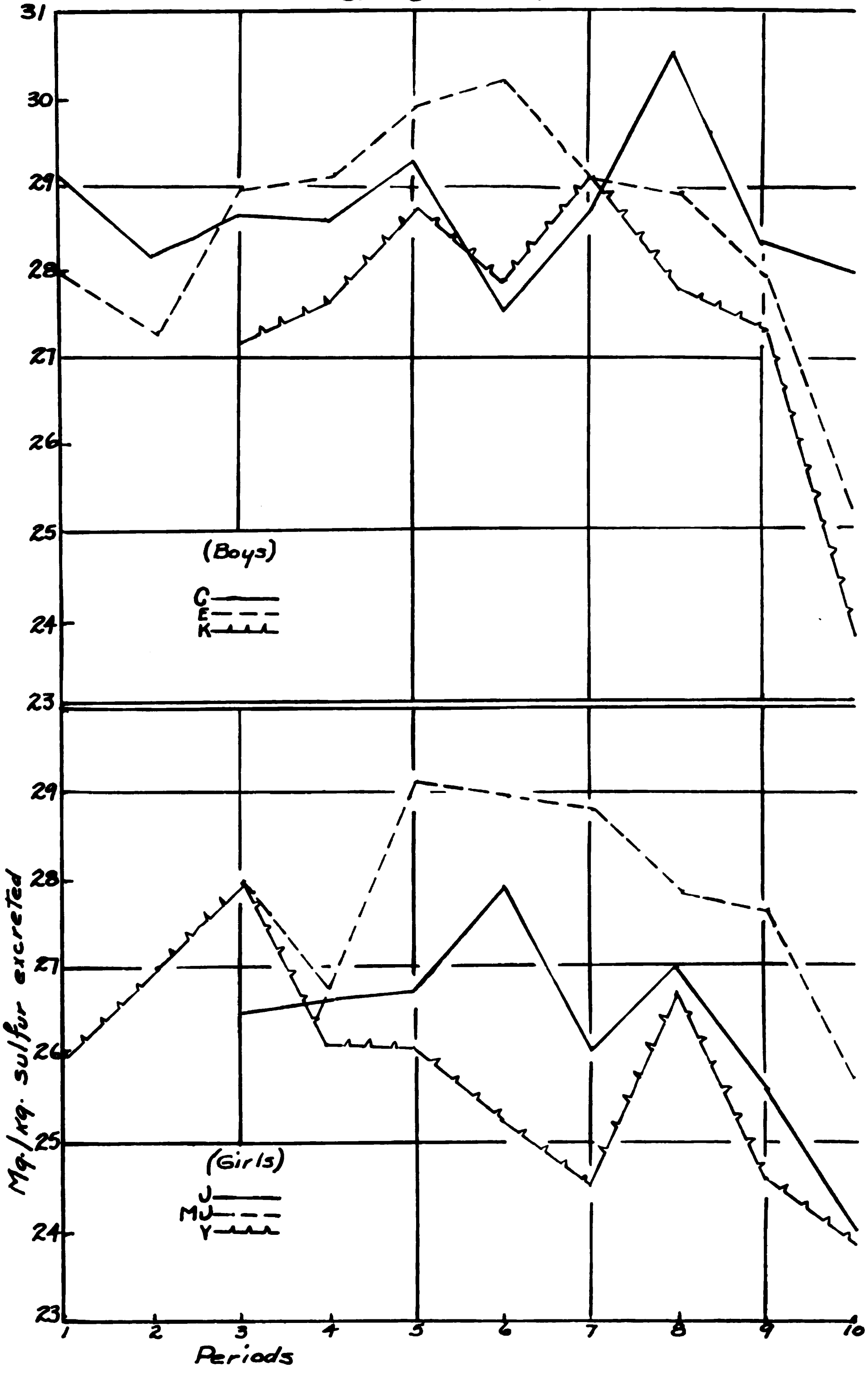


Therefore, since nitrogen and sulfur are so closely associated in food sources, it seems plausible to assume that the above noted variations in sulfur excretion from period to period may have been due in part to variations in dietary sulfur. A second reason for this theory is that the childrens' sulfur excretion curves followed the same general trend, thereby indicating similar inconstancies in dietary sulfur. For example, during three of the periods (numbers 5, 9, and 10), all of the excretions fluctuated in a similar manner, and in three periods (numbers 3, 4, and 6), four of the six fluctuated in the same manner.

The mg. per kilogram sulfur excretions were proportional to the mg. per kilogram intakes since the diets were computed and fed on the basis of kilogram bocy weight. Table 7 and Chart 2 show that the average mg. per kilogram sulfur excretion was quite similar for all of the children. In fact, there was only 3.1 mgs. variation between the highest excretion (28.7 mg.) and the lowest (25.6 mg.). Although C received the smallest amount of food and the second largest amount of sulfur in terms of mgs. per kilogram body weight, he had the highest excretion on this basis. The largest child, E, received the most and excreted the second largest amount of sulfur and the girls both received and excreted less sulfur per kilogram than did the boys. It is evident, then, that the mere weight of the child had no effect on his sulfur excretion--the determining factor being the dietary intake in terms of mgs. of sulfur per kilogram. It is interesting to note that, with one exception, all excretions decreased during the last two periods of the basal diet. This was without doubt due to the fact that while all of the children had gained weight by the end of the period, their

Chart 2.

SULFUR EXCRETION PER KILOGRAM OF BODY WEIGHT ON BASAL DIET



diets were unchanged, thereby reducing their per kilogram food consumption.

There was an individual period variation in the mg. per kilogram sulfur excretions, as was true of the total sulfur excretions (Table 7, Chart 2). But the general trends in variation on the basis of mg. per kilogram excretion were more nearly the same than on the basis of total sulfur excretion. For example, the mg. per kilogram excretion curves of the two boys K and C were identical in their variations except for periods 4 and 8, and the curve of E followed that of K except for periods 6 and 7. The curves of the girls, J, MJ, and Y, were similar with the exception of periods 4, 6, and 8 (Chart 2). It is interesting to note that in periods 3, 5, [illegible] 9, and 10, the variations for all of the children were in the same direction, and during periods 5, 6, and 7, the figures for four of them varied alike.

In order that the degree of variation between children might be determined, each child's average sulfur excretion and his period variations from that average were computed. As may be seen in Table 7 and Chart 3, the child K had the greatest percentage variation from his average excretion, ranging from -13.14 to +6.20, while the child C had the least percentage variation, ranging from -3.83 to +6.27.

The group average figures presented in Table 8 represent an average of all of the children for each period. Under the circumstances, this kind of an average is permissible since all of the children received the same amount of food per kilogram bodyweight. Table 8 and Chart 4 show that the individual excretion figures followed the period group averages very closely. Again, it seems logical to assume that the

Chart 3.

VARIATIONS OF SULFUR EXCRETIONS FROM INDIVIDUAL AVERAGES ON BASAL DIET

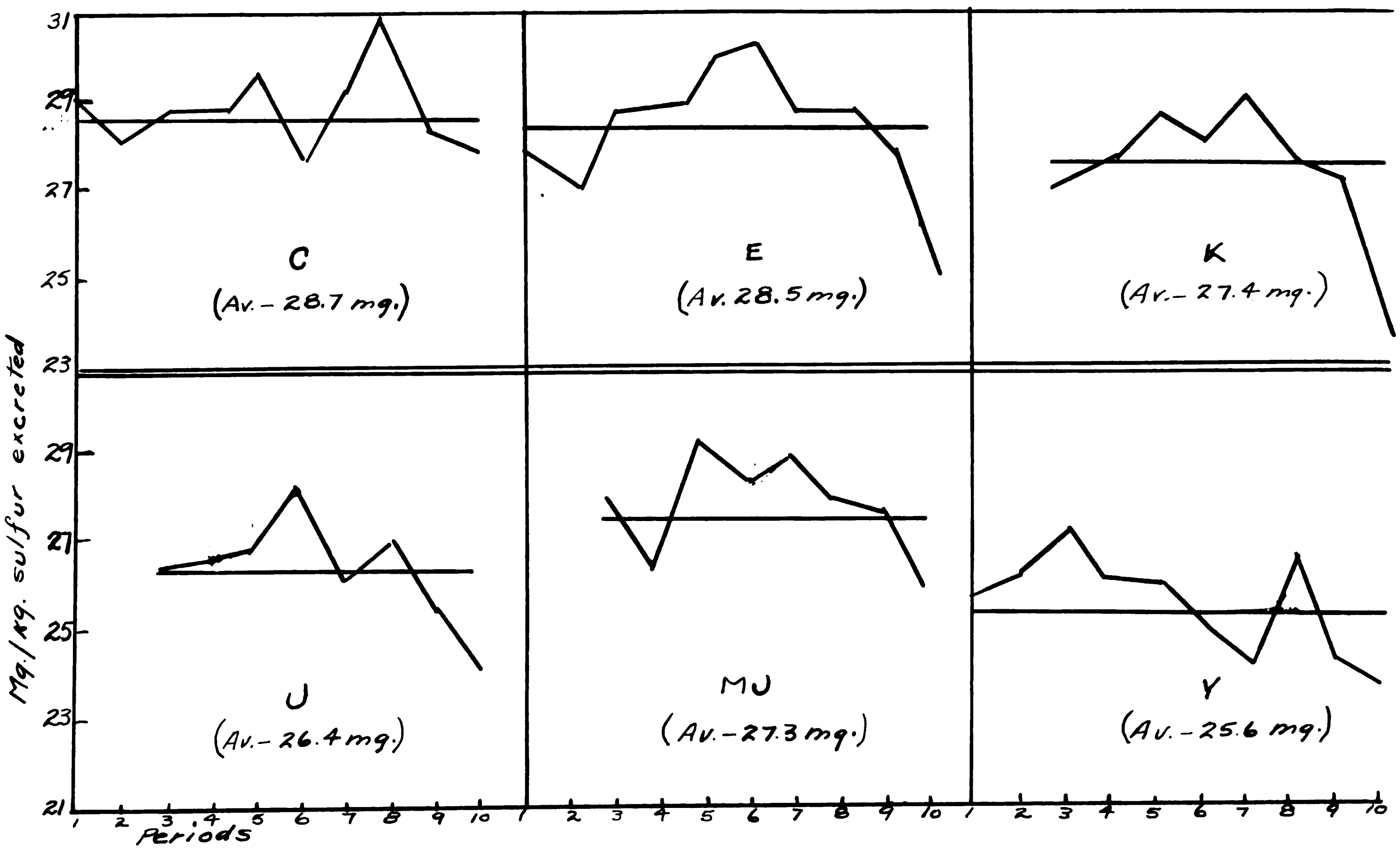
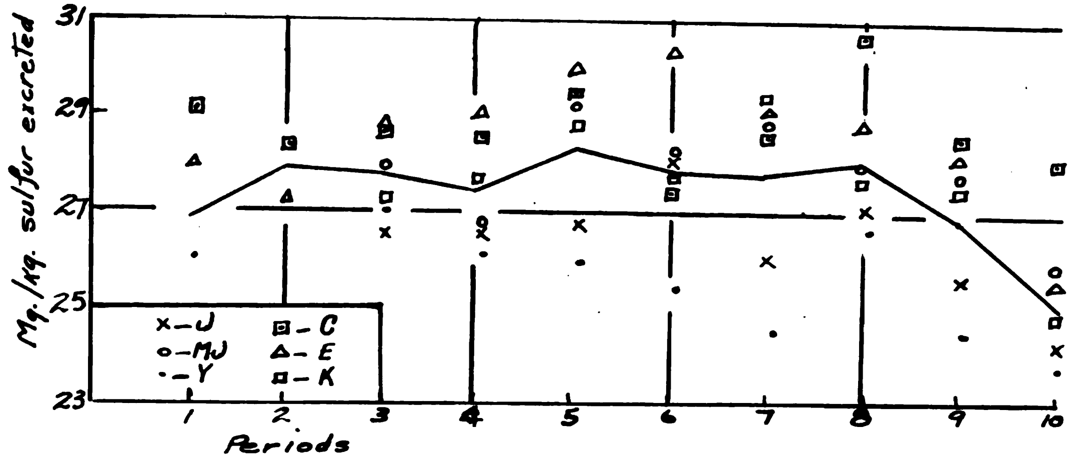


Chart 4.

INDIVIDUAL VARIATION IN EXCRETION FROM PERIOD GROUP AVERAGE ON BASAL DIET



individual variations in sulfur output were due to a great extent to dietary sulfur inconstancies.

TABLE 8

VARIATION OF URINARY SULFUR EXCRETION FROM PERIOD GROUP AVERAGE

Per.	Group Average	Variation (%)					
		C	K	E	MJ	J	Y
	(mg/kg)						
1	27.7	+5.42	-----	+1.01	-----	-----	-6.14
2	27.8	+1.80	-----	-1.80	-----	-----	-----
3	27.7	+3.61	-1.81	+4.33	+0.74	-4.33	-2.53
4	27.5	+4.00	+0.36	+5.82	-2.91	-3.27	-5.09
5	28.3	+3.53	+1.41	+5.30	+3.18	-5.30	-7.77
6	27.9	-1.08	±0	+8.24	+0.72	+0.36	-9.32
7	27.7	+3.97	+5.05	+5.05	+3.97	-5.78	-11.55
8	28.1	+8.54	-1.42	+2.85	-0.71	-3.56	-4.98
9	26.9	+5.20	+1.49	+3.72	+2.60	-4.83	-8.92
10	25.2	+11.11	-5.55	+0.40	+2.38	-3.97	-5.15

Table 9 presents the individual average percentages of dietary sulfur excreted in the urine. The averages varied from 70.0% to 76.4% and were obtained by using the calculated[22] total daily sulfur intake and the average of the daily total sulfur excretion for the entire basal period of each child. Although these figures are inaccurate to the extent that the actual food analysis figures were not used, they were very similar to those presented by Hunscher, Macy, and Cope,[5] who reported 76.43 and 76.26% excretions of dietary sulfur by two children 11 and 7½ years old respectively, on a normal diet over 5 experimental periods of 5 days each.

The percentage of dietary sulfur excreted in the urine apparently had an inverse relationship with the percentage gain in weight (Table 9). For example, the child C excreted the highest percentage of his

TABLE 9

CHANGES IN WEIGHT AND PERCENT OF SULFUR EXCRETED ON BASAL DIET

Child	Change in Weight (kg.)	Change in Weight (%)	Dietary Sulfur Excreted (%)
C	+0.01	0.07	76.7
E	+0.25	1.43	74.8
K	+0.32	1.97	73.9
J	+0.38	2.23	72.3
MJ	+0.34	2.14	73.6
Y	+0.32	1.98	70.1

dietary sulfur and made the least percentage gain in weight while the child Y excreted the lowest percentage of her dietary sulfur and made the second highest percentage gain in weight. Hawks, Dye, and Bray [21] have shown that with an increase in diet nitrogen, there was an attendant increase in retention of nitrogen and also a greater gain in weight. Therefore, because of the close relationship of sulfur and nitrogen, it might be expected that there would be a correlation between sulfur retention and gain in weight also. Although this paper does not present retention figures, it is interesting to note that the children who made the lowest percentage gains in weight (K, C, and E) excreted the highest percentage of their sulfur intakes on the basal diet and therefore may have retained the least sulfur.

Since the greater part of ingested sulfur is contained in protein foods, the sulfur excretion would be expected to parallel that of nitrogen. Several investigators have noted this parallelism and have expressed it as a N/S ratio. Therefore, for purposes of comparison, the N/S ratio of each of the experimental sugjects was determined and presented in Table 10 and Chart 5. The averages of the individual ratios for the entire basal diet ranged from 15.02 to 15.53. Although the average N/S ratios of the children on the basal diet were very nearly the same, each child showed variations from period to period. And again, as was true of the sulfur excretions, these ratios fluctuated in very much the same manner.

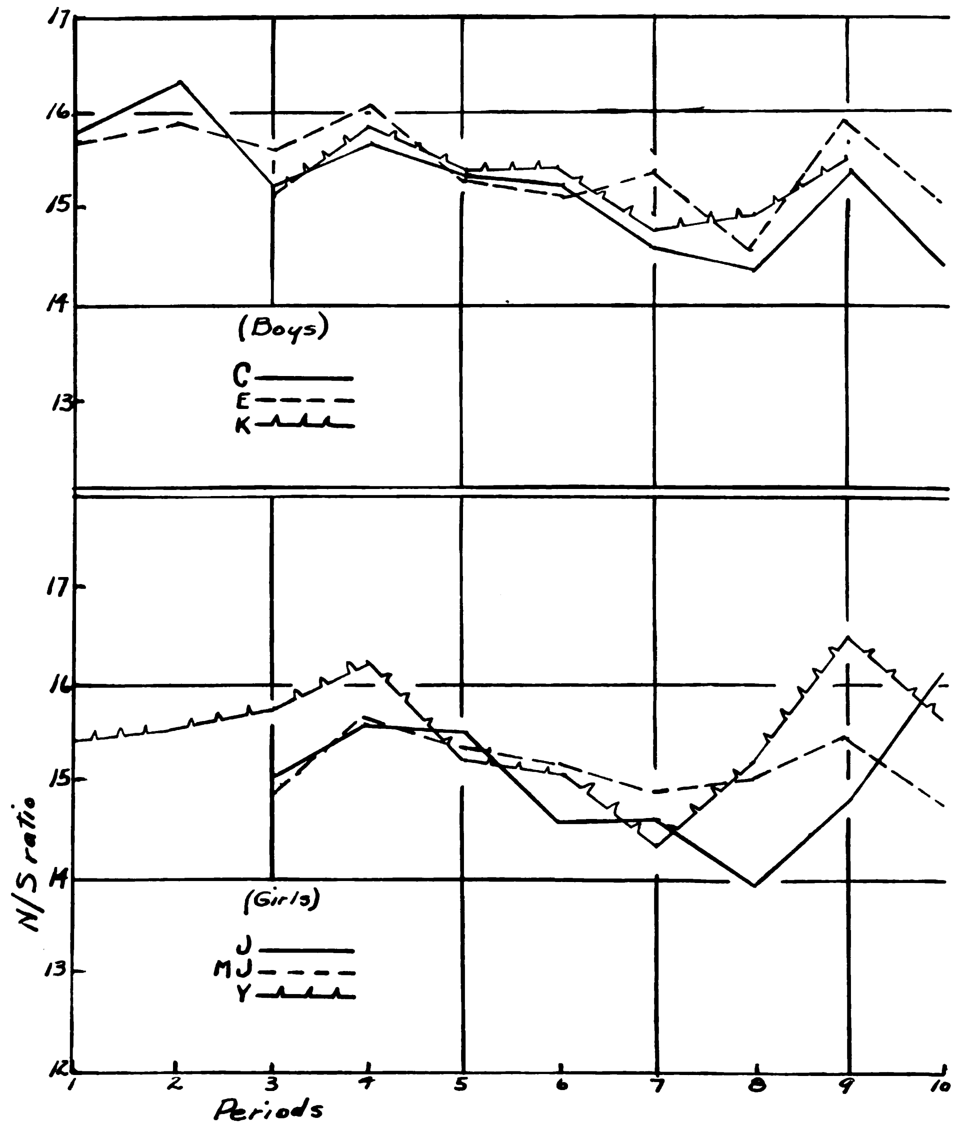
TABLE 10

N/S RATIO ON BASAL DIET

Per.	C		K		E		MJ		J		Y	
	Total N Excreted	N/S Ratio	Total N Excreted	N/S Ratio	Total N Excreted	N/S Ratio	Total N Excreted	N/S Ratio	Total N Excreted	N/S Ratio	Total N Excreted	N/S Ratio
	(mg.)		(mg.)		(mg.)		(mg.)		(mg.)		(mg.)	
1	6891	15.77	----	-----	7613	15.63	----	-----	----	-----	6918	15.48
2	6880	16.25	----	-----	7540	15.86	6456	-----	----	-----	6796	-----
3	6515	15.19	6678	15.14	7644	15.24	6598	14.91	6758	15.00	7278	15.68
4	6707	15.64	7123	15.82	8130	16.02	6657	15.61	7086	15.66	7326	16.24
5	6676	15.28	7137	15.30	7937	15.27	7105	15.28	7028	15.39	6922	15.31
6	6278	15.17	7025	15.41	8030	15.22	6830	15.23	6991	14.63	6665	15.16
7	6302	14.63	7037	14.74	7830	15.40	6840	14.90	6568	14.66	6131	14.36
8	6462	14.43	6775	14.98	7426	14.70	6707	15.08	6462	13.94	7005	15.16
9	6558	15.47	7057	15.67	7776	15.91	6885	15.49	6512	14.72	7116	16.53
10	6036	14.41	----	-----	6724	15.05	6175	14.77	6787	16.14	6567	15.65
Av.		15.22		15.29		15.43		15.53		15.02		15.51

Chart 5.

N/S RATIO ON BASAL DIET



URINARY SULFUR EXCRETION ON HIGH FAT DIET

Previous studies completed in this laboratory demonstrated the necessity for an adjustment period following a change in diet. The investigators found that when the diet nitrogen was increased there was a corresponding increase in nitrogen elimination. The diet change caused a fluctuation in urinary nitrogen which persisted over a period of several days until a state of equilibrium was established. This occurred at the end of about three periods (nine days) following the change in diet. While the modifications in the present study did not involve a change in the mineral content of the diet comparable to the above study, it seemed advisable to reserve the first nine days of each diet phase as an adjustment period.

During the high fat diet the individual average total sulfur excretions of the adjustment periods (numbers 11-13) were very similar to those of the experimental periods (numbers 14-18) as may be seen in Table 11. For example, following the adjustment period, the average excretions of J and & decreased only 0.3 mg. and 2.3 mg. respectively while those of MJ and C increased 4.6 mg. and 6.2 mg. respectively. The greatest change was that of E, whose average excretion increased 13.5 mg. following the adjustment period. It is of interest to note that the two children J and Y whose excretions varied the least had had no change in diet, except for the additional fat. And the child E, whose average excretions differed most widely, had had the greatest

Per.	Child	Weight	Intake	Excretion	Var. From Individual Average
		(kg.)	(mg.)	(mg.)	%
	C				
11		15.11			
12		15.19			
13		15.31			
Av.					
14		15.43			
15		15.58			
16		15.54			
17		15.71			
18		[illegible]			
Av.					
	MJ				
11		[illegible]			
12		[illegible]			
13		[illegible]			
Av.					
14		16.86			
15		16.96			
16		17.06			
17		17.34			
18		17.38			
Av.					

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change in diet. However, none of these differences is significant since they come within the limits of experimental error.

The total sulfur excretions did fluctuate to a much greater extent during the adjustment period than during the following periods, as may be seen in Chart 6. These fluctuations indicate that there was some disturbance in the sulfur metabolism and that the adjustment period was therefore advisable in this study.

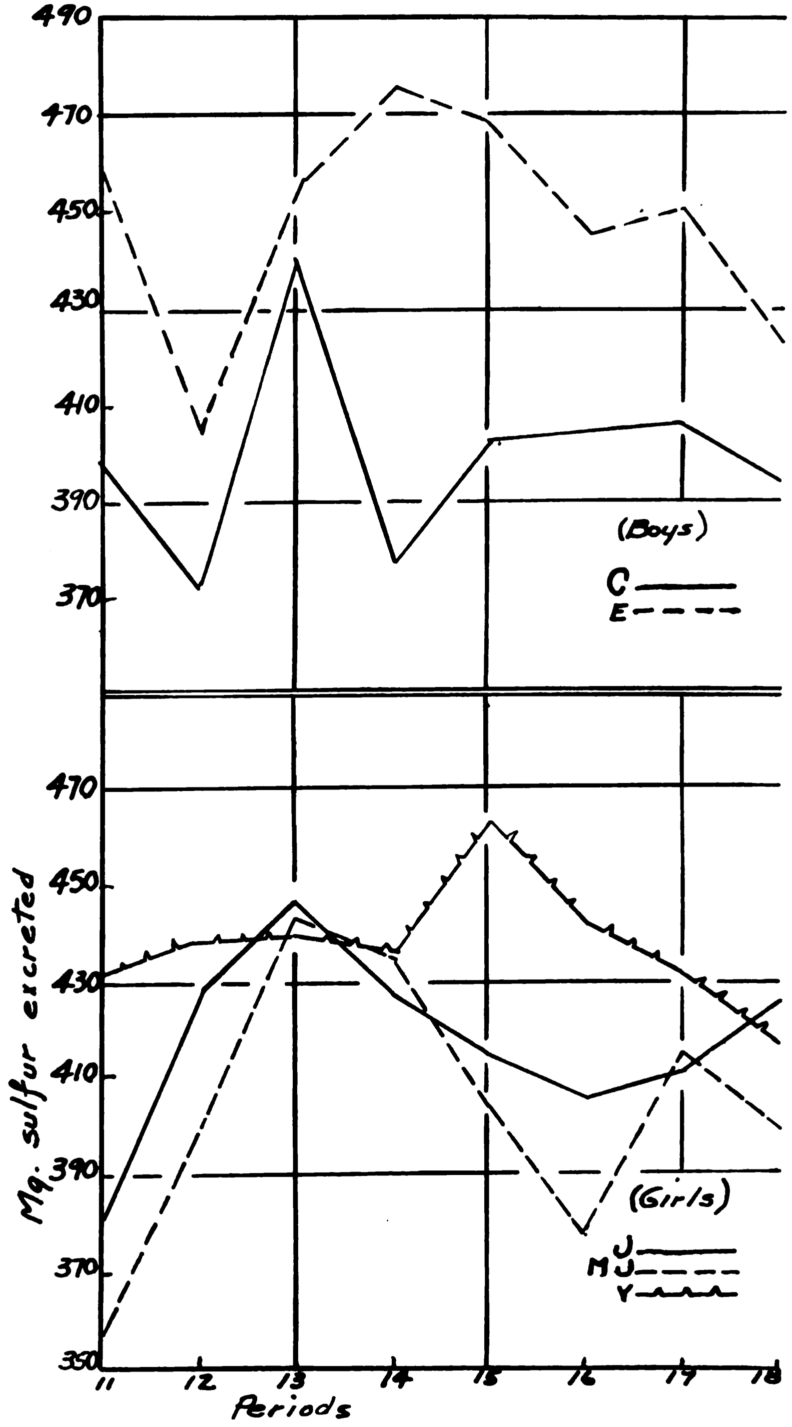
The individual average total urinary sulfur excretions of the children on the high fat diet varied in proportion to the sulfur intake (Table 11). For example, the children E and Y received the largest diets (diet factor .95) and excreted the largest amounts of sulfur—452.5 and 438.1 mg. respectively. The child C received the smallest diet (diet factor .82) and excreted the least sulfur—397.0 mg.

The period to period variations in total sulfur excretion were more nearly alike on the high fat diet than on the basal diet (Table 11, Chart 6). In four of the five periods, the excretions of four of the children varied in the same manner.

The individual average total sulfur excretions were all less on the high fat than the basal diet, which may have been due to one of, or a combination of several causes. First, the diet factors of the children Y and J were unchanged, while those of C, E, and MJ were less, thus decreasing the sulfur intakes. That this may have been the causative factor in the decreased sulfur output was substantiated by the fact that Y who had no change in her diet had less difference between her averages on the basal and high fat diets (5.6 mg.) while E had the greatest change in his diet and also had the greatest difference

Chart 6.

TOTAL SULFUR EXCRETION ON HIGH FAT DIET



between his average excretions (44.3 mg.). Secondly, all of the children gained weight more rapidly on the high fat diet. While the highest percentage gain in weight on the basal diet was 3%, the lowest and highest gains in weight on the high fat diet were 5.16 and 7.28% respectively (Table 12). Thus the more rapid rate of growth may have caused a greater retention of sulfur.

TABLE 12

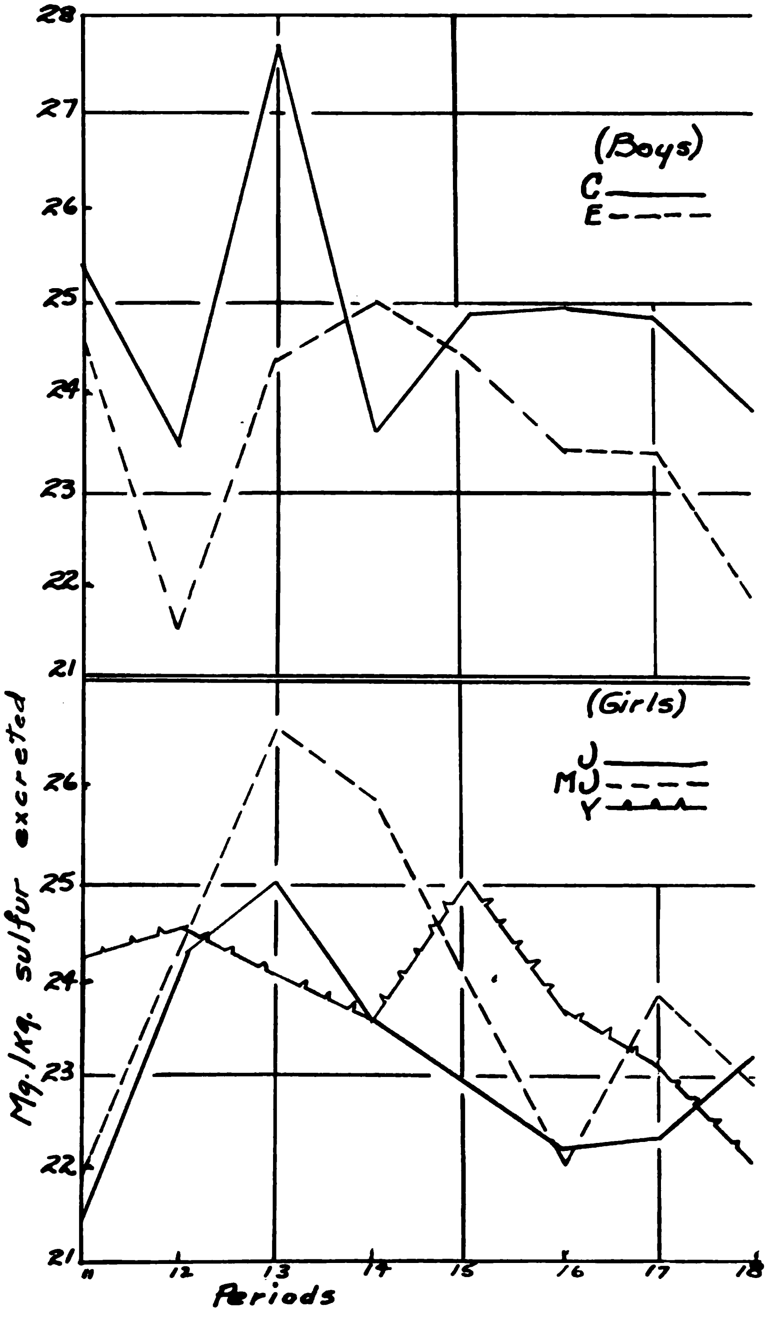
RELATION BETWEEN CHANGES IN WEIGHT AND PER CENT SULFUR EXCRETION ON HIGH FAT DIET

Child	Change In Weight		Dietary Sulfur Excreted
	(kg.)	(%)	(%)
C	+0.88	5.89	71.8
E	+0.91	5.16	70.8
MJ	+1.18	7.28	69.1
J	+1.04	5.92	65.8
Y	+1.24	7.11	68.1
Av.			69.3

The individual average mg. per kilogram excretions on the high fat diet varied from 22.8 mg. (J) to 25.4 mg. (C) (Table 13, Chart 7). Thus there was only 2.9 mg. difference between the highest and lowest average excretions--even less than on the basal diet. The calculated average intake varied but 1.1 mg. from the highest to the lowest, which was also less than that noted on the basal diet. Again, the child C received the smallest total amount of food but actually received more sulfur per kilogram and excreted more on this basis than

Chart 7.

SULFUR EXCRETION PER KILOGRAM OF BODY WEIGHT ON HIGH FAT DIET



did the other children. It is interesting to note that on this diet as on the basal, all excretions but one decreased in the last period of the diet. Again, this was no doubt due to the fact that the increase in weight caused a corresponding decreased intake per kilogram.

There was an individual period to period variation in the mg. per kilogram excretions as may be seen in Table 13 and Chart 7. However, the fluctuations were more uniform than those on the basal diet. For example, in periods 14, 16, and 18, four of the five excretions varied in the same direction while in period 17 there was practically no change in four of the excretions. These figures again emphasize the probability of a common dietary variation.

The period to period variations from the individual averages were less than on the basal diet as shown in Table 13 and Chart 8. For example, MJ had the greatest percentage range from her individual average--from -6.75 to +8.86, while C had the least--from -3.15 to +2.36.

The excretions of all the children except C and J showed closer conformation with the group period averages than with the individual diet averages (Table 14, Chart 9). In other words, each child except C and J had a greater percentage range in variation above and below his individual average than above and below the group average.

The average percentages of dietary sulfur excreted on the high fat diet varied from 65.8 to 71.8% (Table 12). Thus, although the children received less total sulfur, they apparently retained a greater percentage of that ingested, since on the basal diet the lowest percentage excreted was 70.0%. It is interesting to note here also that

Chart 8.

VARIATIONS OF SULFUR EXCRETIONS FROM INDIVIDUAL AVERAGES ON HIGH FAT DIET

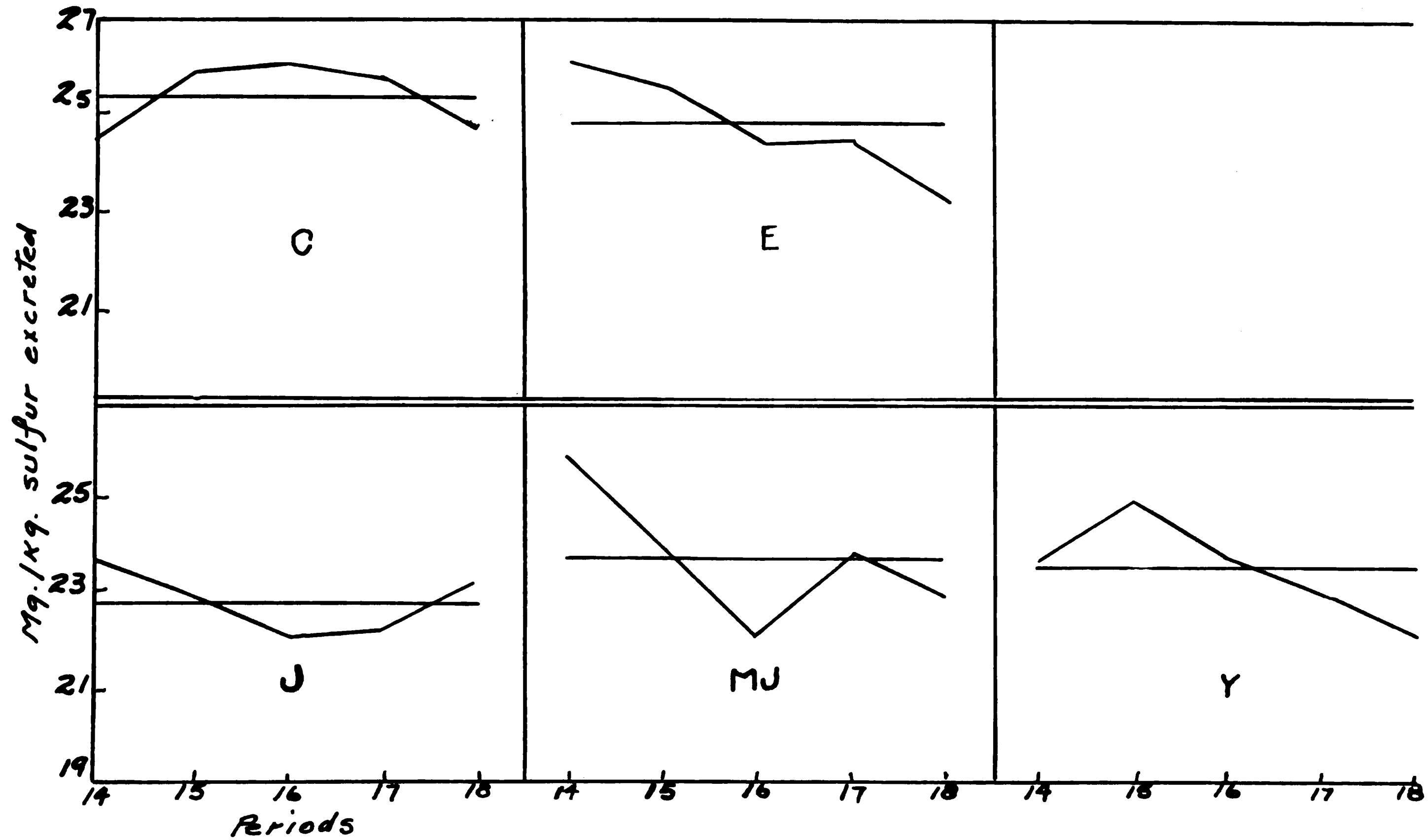


TABLE 14

INDIVIDUAL VARIATION OF URINARY SULFUR FROM PERIOD GROUP AVERAGE ON HIGH FAT DIET

Per.	Group Av.	Variation (%)				
		C	E	MJ	J	Y
	(mg./kg.)					
14	24.7	-0.40	+5.67	+4.45	-4.45	-4.45
15	24.6	+5.28	+3.66	-2.85	-6.91	+1.63
16	23.7	+9.70	+2.95	-6.75	-6.33	±0
17	23.9	+7.95	+2.09	-0.42	-6.69	-3.35
18	23.2	+6.90	-0.86	-1.29	±0	-4.74

the two children who had no change in diet (J and Y) also excreted the least percentage of their dietary sulfur.

Again there was a correlation between gain in weight and per cent of dietary sulfur excreted. The two children C and E (both boys) made the least per cent gains in weight (5.89 and 5.16%, respectively) and they also excreted the greatest per cent of their dietary sulfur (71.8 and 70.8%, respectively).

The individual average N/S ratios were quite similar, varying only from 15.0 to 15.15 (Table 15). Four of the five children showed a slight decrease in their individual average N/S ratios from those on the preceding basal diet, but the decrease was too small to be significant.

As seen in Chart 10, the N/S ratios followed the same general trends. The boys' curves (C and E) were almost identical while the girls' were less similar.

Chart 9.

INDIVIDUAL VARIATION IN EXCRETION FROM PERIOD GROUP AVERAGE ON HIGH FAT DIET

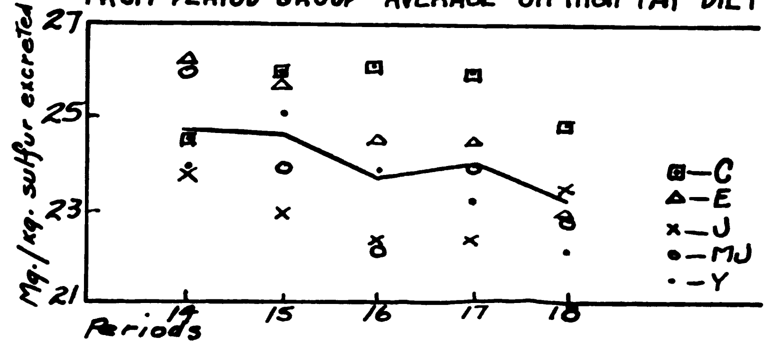


Chart 10.

N/S RATIO ON HIGH FAT DIET

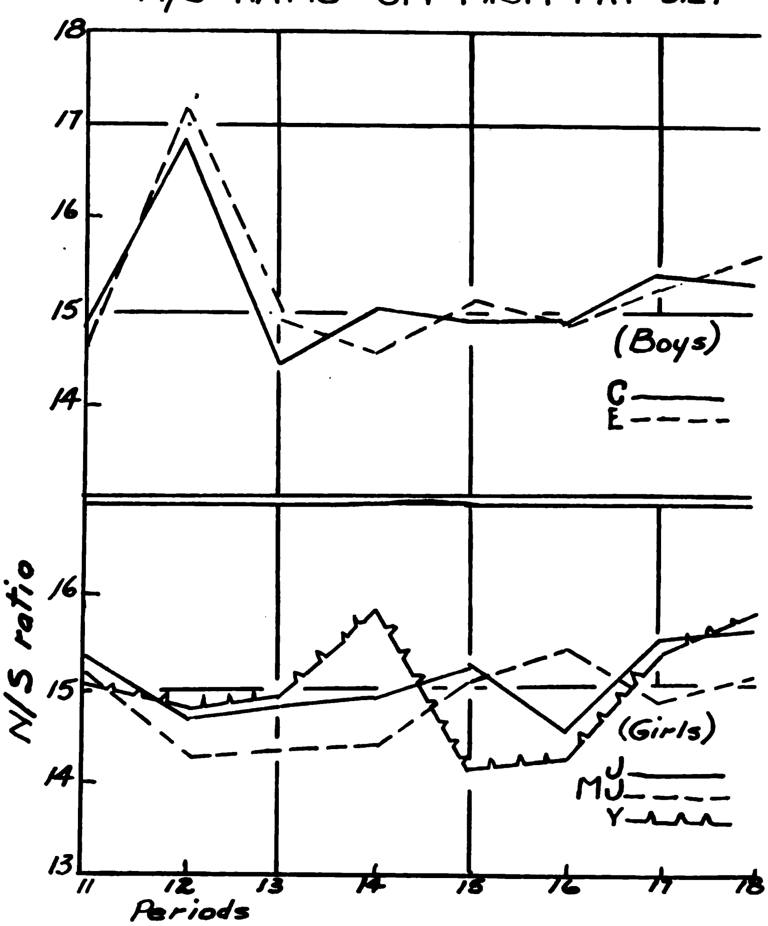


TABLE 15

N/S RATIO ON HIGH FAT DIET

Per.	C		E		MJ		J		Y	
	Total N Excreted	N/S Ratio	Total N Excreted	N/S Ratio	Total N Excreted	N/S Ratio	Total N Excreted	N/S Ratio	Total N Excreted	N/S Ratio
	(mg.)		(mg.)		(mg.)		(mg.)		(mg.)	
11	5925	14.89	6736	14.70	5386	15.07	5791	15.28	6475	15.00
12	6269	16.83	6914	17.16	5719	14.24	6336	14.75	6500	14.8
13	6364	14.48	6812	14.94	6362	14.32	6649	14.87	6528	14.95
Av.		15.40		15.60		14.54		14.97		14.9
14	5721	15.09	6938	14.66	6281	14.42	6388	14.89	6897	15.88
15	6034	14.98	7034	15.08	6102	15.09	6327	15.20	6538	14.11
16	6043	14.93	6656	14.90	5833	15.47	5907	14.53	6315	14.28
17	6236	15.41	6953	15.44	6135	14.84	6351	15.40	6695	15.42
18	6039	15.36	6634	15.59	6038	15.14	6639	15.53	6531	15.69
Av.		15.15		15.13		15.00		15.11		15.08

URINARY SULFUR EXCRETION ON HIGH STARCH DIET

The remainder of this study will include the excretion figures of only three children (Y, C, and E) inasmuch as the other two (MJ and J) failed to consume the diets quantitatively in several of the periods.

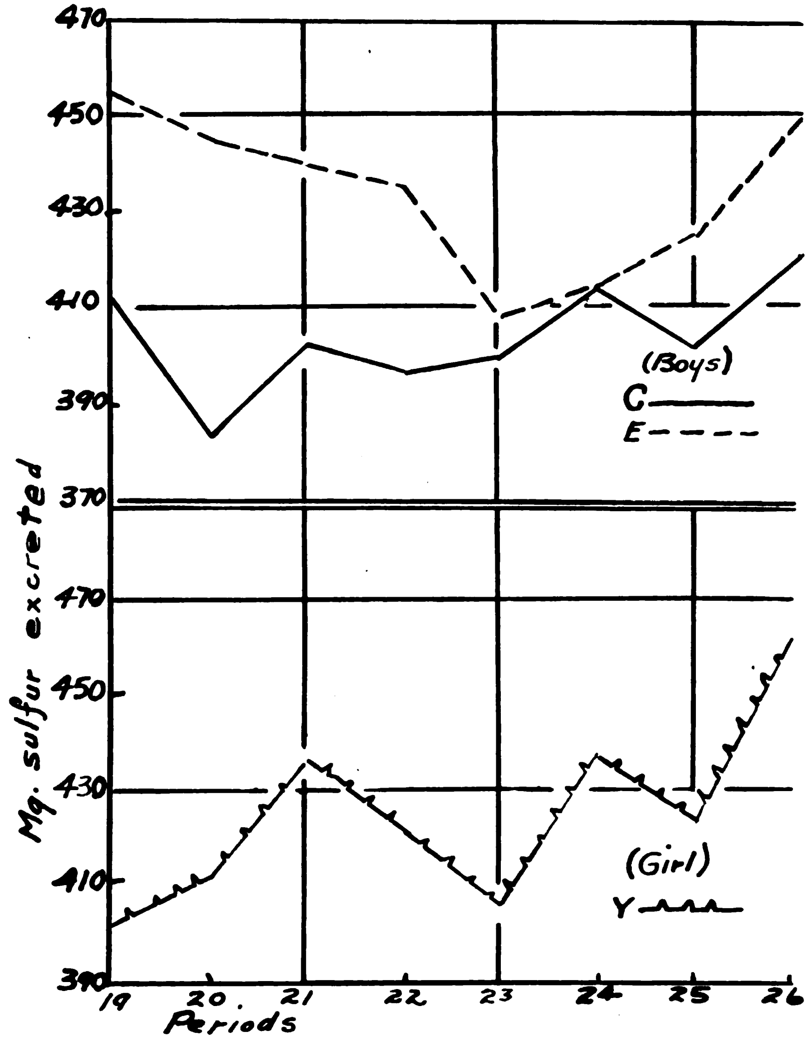
The individual average total sulfur excretions of the adjustment periods (numbers 19-21) varied little from those of the periods following (numbers 22-26) as shown in Table 16. During the latter periods the average excretions of C and Y increased 6.0 mg. and 13.6 mg. respectively, while that of E increased 20.9 mg. Although these differences were not large enough to be significant, they were all greater than on the preceding diet. It is also interesting to note that the same child (C) had the largest variation between his average excretions for the adjustment periods on both this and the high fat diet. This fact probably indicates that the change in diet produced a different effect on the sulfur metabolisms of the individual children.

The total sulfur excretions fluctuated to no greater extent during the adjustment periods than the following periods (Chart 11). From this chart it would seem that the adjustment period probably was not necessary on the high starch diet since the cornstarch seemed to cause little, if any, disturbance to the sulfur metabolism of any of the children.

On the high starch diets, as was true on the basal and high fat

Chart II.

TOTAL SULFUR EXCRETION ON HIGH STARCH DIET



Per.	Child	We[illegible]
	C	
19		[illegible]
20		[illegible]
21		[illegible]
Av.		[illegible]
22		[illegible]
23		[illegible]
24		[illegible]
25		[illegible]
26		[illegible]
Av.		[illegible]
	Y	
19		[illegible]
20		[illegible]
21		[illegible]
Av.		[illegible]
22		[illegible]
23		[illegible]
24		[illegible]
25		[illegible]
26		[illegible]
Av.		[illegible]

diets, the average urinary total sulfur excretions varied in accordance with the dietary intakes (Table 16). Again the two children E and Y received the larger amounts of food, (diet factor .95), and excreted the largest amounts of sulfur (426.4 mg. and 431.1 mg. respectively). The child C had the smaller daily food intake, (diet factor .82), and excreted the least sulfur, 405.8 mg.

The period to period variations in total sulfur excretions were quite similar (Chart 11). While all of the excretions varied in the same direction in only three of the five diet periods (22, 24, and 26), the general trends of the individual excretions were more uniform than on the preceding diets.

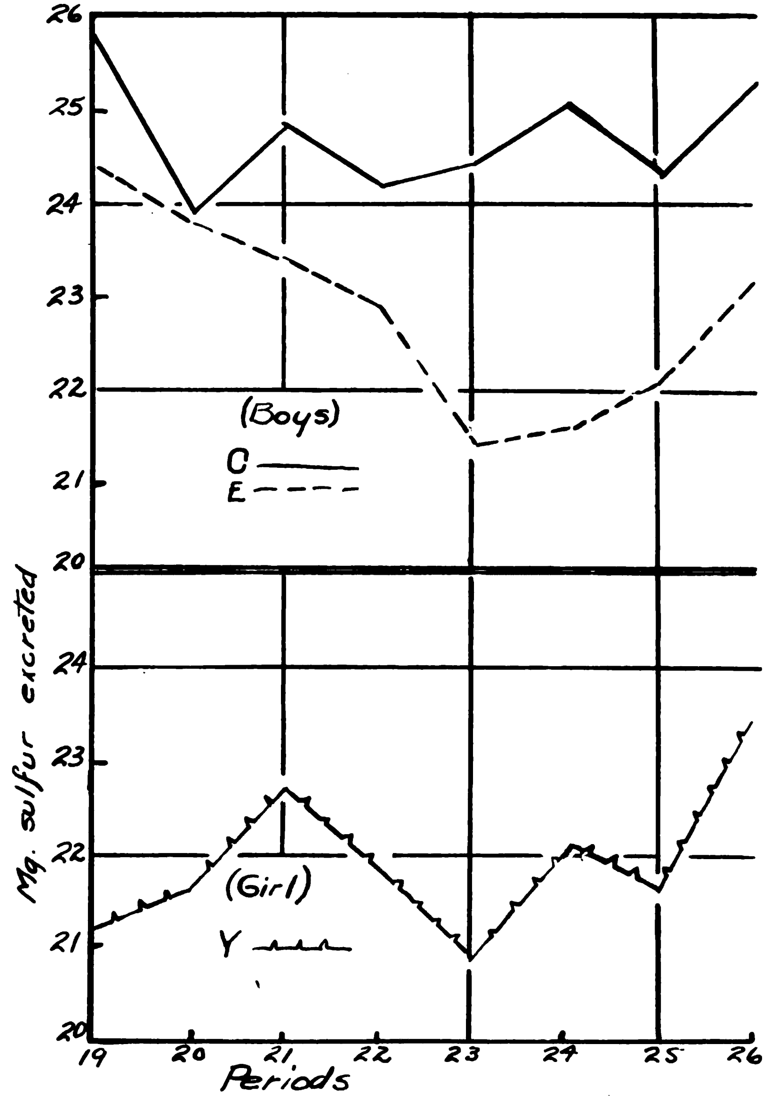
The average total sulfur excretions of the two children E and Y were less on the high starch than on the high fat diet (26.1 mg. and 7.0 mg., respectively). The excretion of child C (405.8 mg.) showed a slight increase of 8.8 mg. over that of the high fat period. All variations were too small, however, to be significant. The individual average excretions, without exception, varied less from the high fat to high starch than from the basal to high fat diets. This was possibly due to the fact that the average sulfur intakes varied less from the high fat to high starch than from the basal to the high fat diet, or to the fact that additional calories produced the same changes whether they came from fat or starch.

The individual average mg. per kilogram urinary sulfur excretions during this diet varied from 21.9 mg. (Y) to 24.7 mg. (C), as seen in Table 17 and Chart 12. Thus these values were progressively lower during the basal, high fat, and high starch diets, as were the dietary

Per.
19
20
21
Av.
22
23
24
25
26
Av.

Chart 12.

SULFUR EXCRETION PER KILOGRAM OF BODY WEIGHT ON HIGH STARCH DIET



sulfur intakes on the basis of mg. per kilogram. Although the calculated average mg. per kilogram intakes varied only 0.1 mg. from the lowest to the highest, the difference in excretions was 2.8 mg. This figure was practically the same as the difference on the high fat diet of 2.9 mg. The child C again excreted more sulfur per kilogram than the other children, even though he received the same amount of sulfur per kilogram. In contrast to the other diet figures, all excretions increased during the last period of the high starch diet. It seems probable that this was caused by a fluctuation in dietary sulfur rather than any disturbance to mineral metabolism.

The same similarity between individual mg. per kilogram excretion curves evident in the preceding two diets was true of this diet also (Table 17, Chart 12). All of the childrens' excretion curves varied in the same direction in three of the five periods. The boys' curves did not show the marked similarity which they had on the other diets, however.

The mg. per kilogram excretions from period to period fluctuated less above and below the individual averages than on the two preceding diets (Table 17, Chart 13). For example, the greatest range in variation was that of Y (+6.85 to -5.02) while the smallest was that of C (+2.43 to -2.02).

Two of the individual mg. per kilogram excretions (E and Y) again varied less from the group average than from their individual averages (Table 18, Chart 14). Subject C had a total range in variation of 4.45 from his individual average and 4.70 from the group average, a difference which is not significant.

Chart 13.

VARIATIONS OF SULFUR EXCRETIONS FROM INDIVIDUAL AVERAGES ON HIGH STARCH DIET

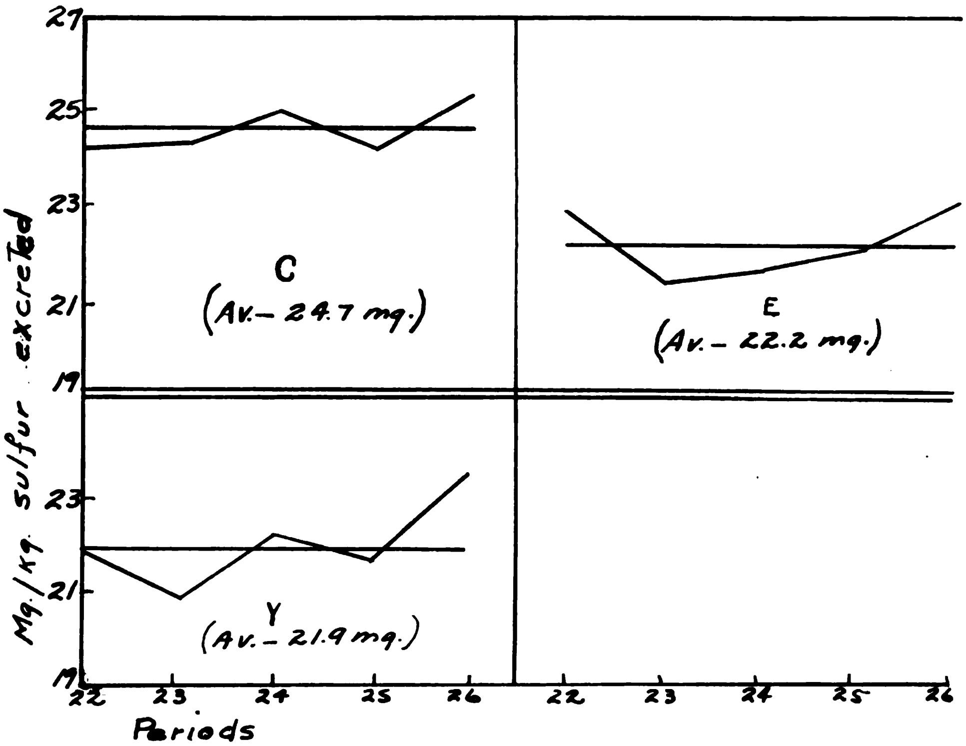


Chart 14.

INDIVIDUAL VARIATION IN EXCRETION FROM PERIOD GROUP AVERAGE ON HIGH STARCH DIET

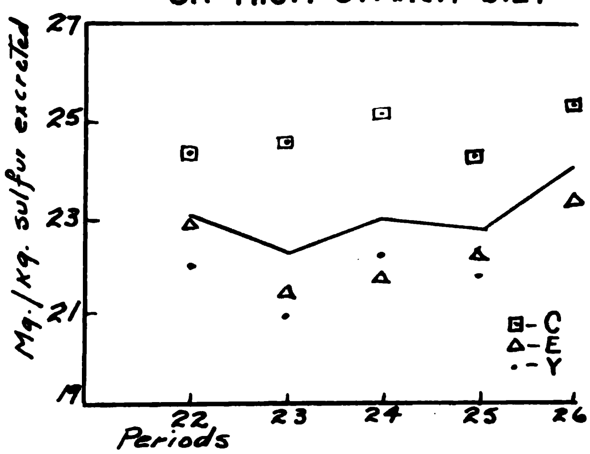


TABLE 18

INDIVIDUAL VARIATION OF URINARY SULFUR FROM PERIOD GROUP AVERAGE ON HIGH STARCH DIET

Per.	Group Av.	Variation (%)		
		C	E	Y
	(mg./kg.)			
22	23.0	+5.22	-0.44	-5.22
23	22.2	+9.92	-3.61	-6.33
24	22.9	+9.62	-5.68	-3.49
25	22.7	+7.07	-2.64	-4.85
26	24.0	+5.41	-3.33	-2.50

The average percentage of dietary sulfur excreted varied from 67.6% to 75.5% (Table 19) which were lower values than on the other diets. Since each of the children received less sulfur per kilogram on this than on the other diets, it would appear that with one exception (C), they retained a greater amount of the sulfur ingested.

TABLE 19

RELATION BETWEEN CHANGES IN WEIGHT AND PERCENT SULFUR EXCRETION ON HIGH STARCH DIET

Child	Change In Weight		Dietary Sulfur Excreted
	(kg.)	(%)	(%)
C	+0.68	+4.26	75.5
E	+0.72	+3.88	67.9
Y	+0.95	+5.05	67.6

Each child received a calculated 20% increase in calories over the basal diet. Therefore we might have expected a gain in weight comparable to the last diet. However, there was a smaller gain in weight in all cases with an accompanying increase in sulfur excretion of only child C. E and Y had slight decreases in their percentages of dietary sulfur excreted. The child Y had the greatest percentage gain in weight and the lowest sulfur excretion on the basis of percentage of sulfur ingested. If the actual calories were the same on both diets, the preceding conclusion that greater retention of sulfur paralleled greater gains in weight was erroneous.

The average N/S ratios varied from 14.90 (C) to 15.05 (E). These ratios were slightly lower than on the high fat diet, but not significantly so. The ratios were also far less variable on this than on the preceding diets, as may be seen in Chart 15 and Tables 20 and 21. For example, child Y had the greatest range in variation from her lowest to highest N/S ratio (14.70 to 15.41), which was less than half as great as her range on the high fat diet (14.11 to 15.88). From the foregoing figures we might conclude that the apparent greater uniformity in sulfur excretion on the high starch diet was due to one of two causes. First, there may have been less variation in dietary sulfur during the high starch diet. Second, the additional calories in the form of cornstarch may have been less disturbing to the sulfur metabolisms of the children than the additional fat.

Chart 15.

N/S RATIO ON HIGH STARCH DIET

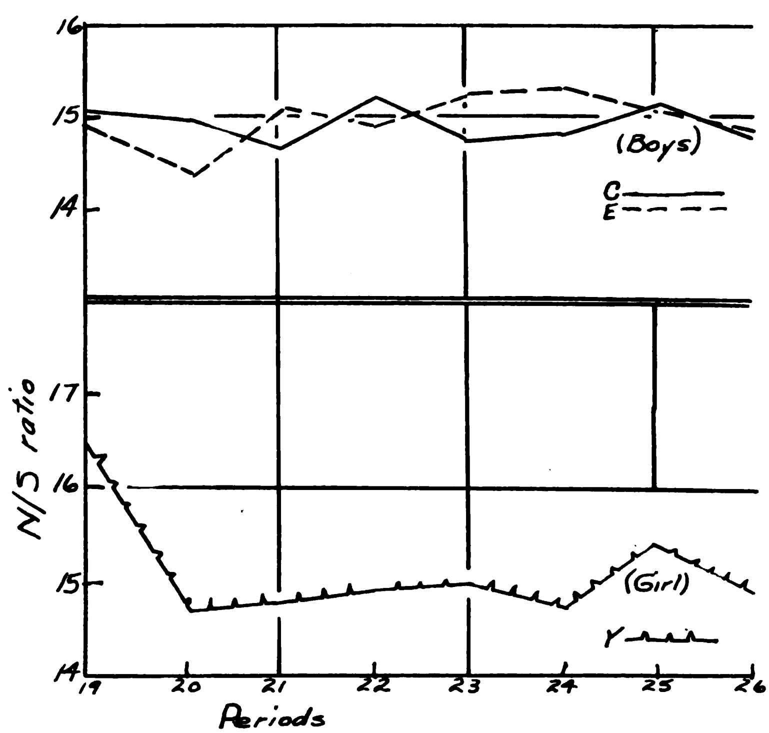


TABLE 20

N/S RATIO ON HIGH STARCH DIET

Per.	C Total N Excreted	C N/S Ratio	E Total N Excreted	E N/S Ratio	Y Total N Excreted	Y N/S Ratio
	(mg.)		(mg.)		(mg.)	
19	6194	15.02	6761	14.85	6643	16.52
20	5745	14.95	6420	14.38	6093	14.74
21	5896	14.64	6621	15.04	6481	14.82
Av.		14.87		14.76		15.36
22	6010	15.22	6507	14.96	6288	14.87
23	5865	14.69	6196	15.16	6103	14.99
24	6099	14.73	6343	15.31	6423	14.70
25	6075	15.10	6428	15.07	6558	15.41
26	6169	14.75	6612	14.77	6868	14.84
Av.		14.90		15.05		14.96

TABLE 21

RANGE IN VARIATION OF N/S RATIOS ON HIGH STARCH DIET

Child	Av.	Highest	Lowest	Range
C		15.22	14.69	0.53
E		15.31	14.77	0.54
MJ		15.71	14.41	1.30
Y		15.41	14.70	0.71

URINARY SULFUR EXCRETION ON HIGH SUGAR DIET

The individual average total sulfur excretions of the adjustment periods (numbers 27-29) differed little from those of the following diet periods (numbers 30-34) as may be seen in Table 22. The average excretions of C and Y showed an increase of 2.5 mg. and 24.2 mg. respectively while that of E decreased 9.1 mg.

The high sugar diet varied from the others in that all of the childrens' excretions varied in the same direction in one of the adjustment periods (27), while they were not all alike in any other period of the diet. This points to individual differences in sulfur metabolism rather than common dietary inconstancies.

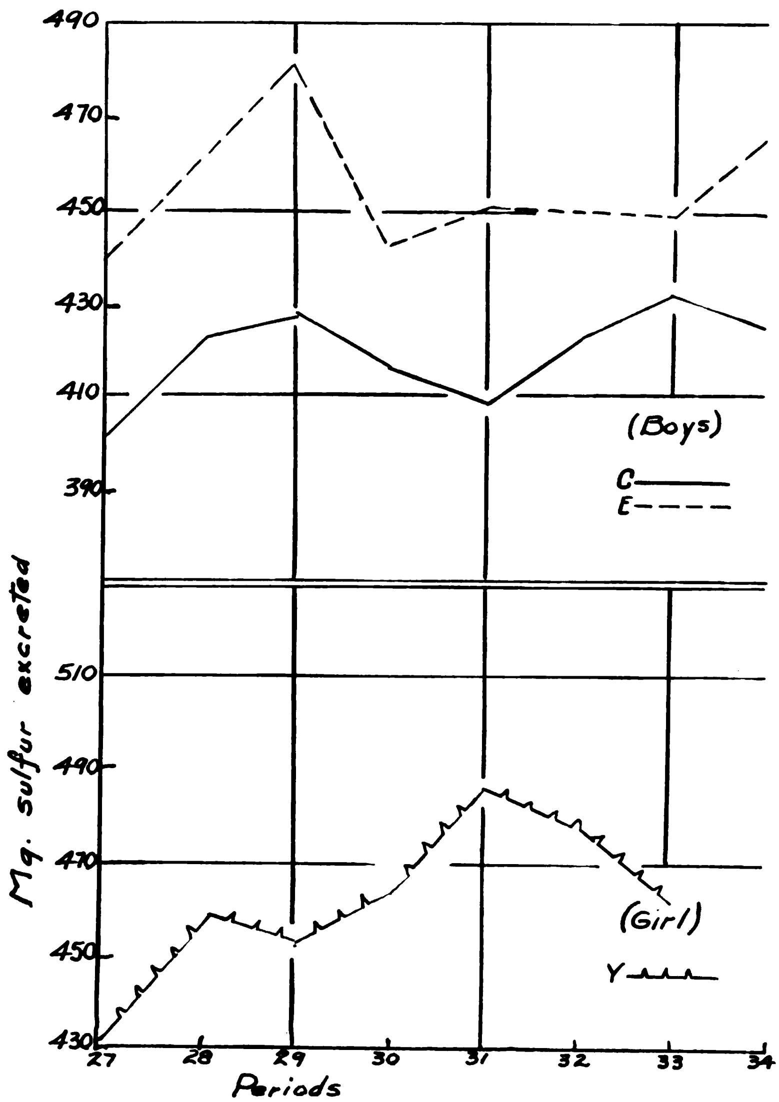
Again the individual average urinary sulfur excretions varied with the dietary intakes. Y had the greatest average excretion (472.4 mg.) and also had the highest average intake (705.0 mg.) as seen in Table 22. The child C excreted the least total sulfur (420.4 mg.) and had the smallest intake (592.0 mg.). All of the children had a larger total sulfur intake and a larger excretion on this than any of the other diets, except the two boys C and E who had greater excretions of sulfur on the basal diet.

The individual period to period variations in total sulfur elimination were not so similar as on the previous diets. In no period were all excretions in the same direction. The boys, however, did show a close similarity in their excretions (Chart 16).

Per.	Child	WeiWeight	To	Var. From ...vidual ...e
		(kg.)		
	C			
27		8		
28				
29				
Av.				
30		1		
31		1		
32		1 2		
33		1 20		
34		1 21.		
Av.		1 20.55		

Chart 16.

TOTAL SULFUR EXCRETION
ON HIGH SUGAR DIET



The highest average mg. per kilogram sulfur excretion was 24.6 mg. (C) and the lowest was 22.6 mg. (Y) as seen in Chart 17 and Table 23. C also had the highest average sulfur intake (34.9 mg.) while E had the lowest (34.3 mg.) on the basis of mg. per kilogram. The 1.8 mg. variation between individual average excretions from lowest to highest was less on this than on any other diet of the study. The calculated dietary sulfur intake per kilogram varied only 0.6 mg. from the lowest to the highest.

The individual period to period variations were quite similar for the boys C and E. The excretion curve of the girl, Y, however, showed little agreement with the other two. The fact that she was gaining weight more rapidly may have tended to affect the regularity of her sulfur metabolism.

The mg. per kilogram excretions varied above and below the individual averages on the high sugar diet less than on any of the preceding diets (Table 23, Chart 18). For example, the values for E varied the least from his average, -1.33 to +1.77%. Y again had the greatest variation ranging from -3.51 to +3.51%. Both E and Y showed a markedly smaller range in variation from their individual average excretions on the high sugar diet. C had practically the same range as he had on the high starch diet.

Table 24 and Chart 19 show the individual variation from the period group averages. E and Y both had greater ranges in variation from their individual averages than from the group averages. In this as well as the other diets C had a greater range in variation from the group average than from his individual average. Evidently if there

Chart 17.

SULFUR EXCRETION PER KILOGRAM OF BODY WEIGHT ON HIGH SUGAR DIET

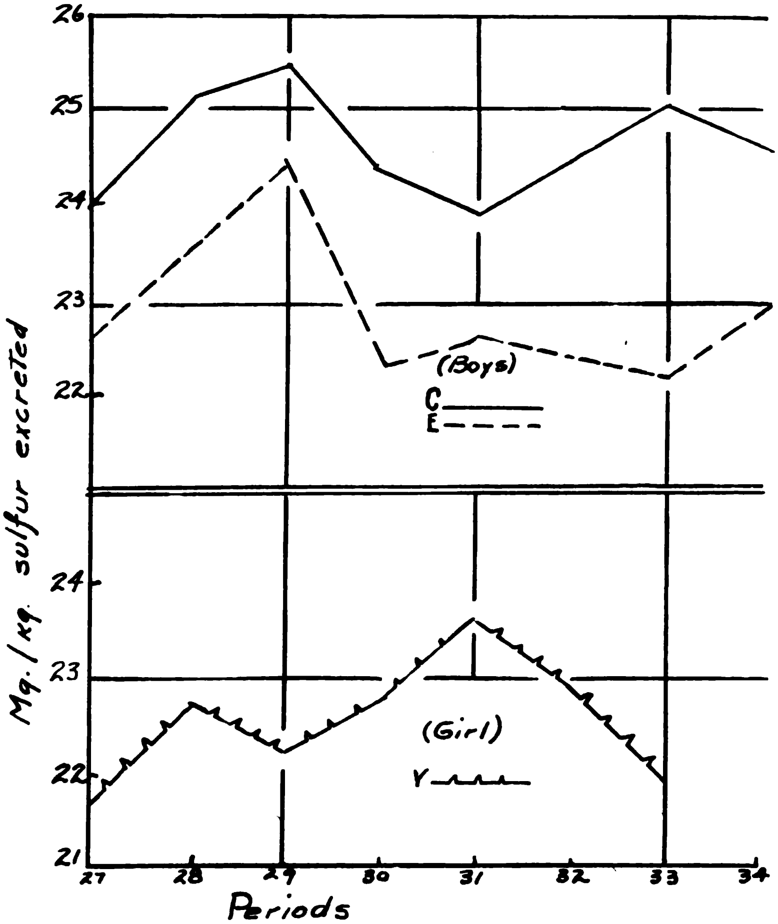


Chart 18.

VARIATIONS OF SULFUR EXCRETIONS FROM INDIVIDUAL AVERAGES ON HIGH SUGAR DIET

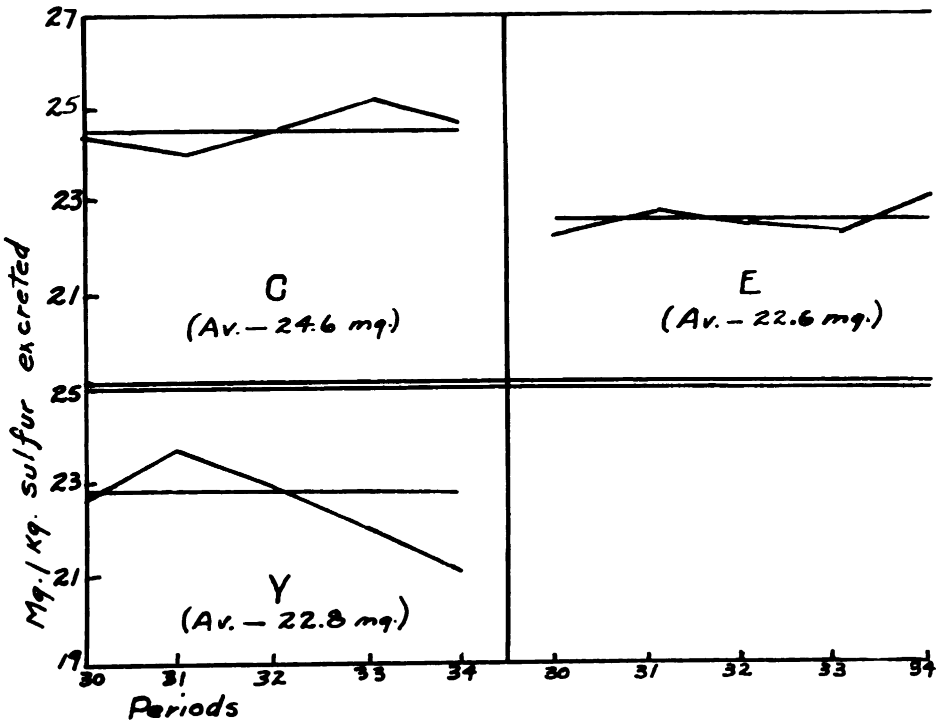
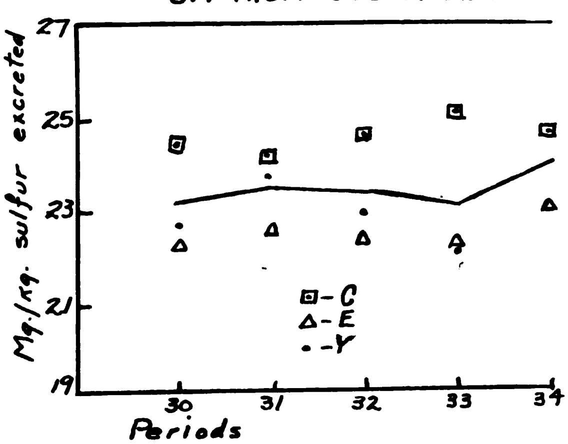


Chart 19.

INDIVIDUAL VARIATION IN EXCRETION FROM PERIOD GROUP AVERAGE ON HIGH SUGAR DIET



were any dietary variations causing the fluctuarions in excretion, C was less affected by them than were the other children.

TABLE 24

INDIVIDUAL VARIATION OF URINARY SULFUR FROM PERIOD GROUP AVERAGE ON HIGH SUGAR DIET

Per.	Group Av.	Variation (%)		
		C	E	Y
	(mg./kg.)			
30	23.1	+5.63	-3.46	-1.73
31	23.4	+2.56	-2.98	+0.86
32	23.3	+5.58	-3.42	-1.71
33	23.1	+8.68	-3.46	-4.77
34	23.9	+3.34	-3.76	-----

The average percentages of dietary sulfur excreted ranged from 65.3% (E) to 70.5% (Y) (Table 25). Thus the average of each child was lower on this than on any of the preceding diets. Since the variations from both individual and group averages were also less on this diet, it would appear that the sulfur content of the high sugar diet was more constant. Therefore, the children retained a greater amount of sulfur.

There was a correlation between change in weight and amount of sulfur excreted as on the other diets (Table 25). C made the least percentage gain in weight (4.18%) and also excreted the greatest percentage of his dietary sulfur (70.5%). Y made the greatest percentage gain in weight (6.28%) and excreted the second smallest percentage of her dietary sulfur (66.5%).

TABLE 25

RELATION BETWEEN CHANGES IN WEIGHT AND PERCENT SULFUR EXCRETION ON HIGH SUGAR DIET

Child	Change In Weight		Dietary Sulfur Excreted
	(kg.)	(%)	(%)
C	+0.69	+4.18	70.5
E	+0.87	+4.52	65.3
Y	+1.24	+6.28	66.5

The average N/S ratios ranged from 14.73 (C) to 15.13 (E)(Table 26, Chart 20). These averages of C and Y were lower than they had been in any of the preceding diets. E had the same average ratio on this and the high fat diets--his lowest ratio was on the high starch diet.

TABLE 26

N/S RATIO ON HIGH SUGAR DIET

Per.	C Total N Excreted	C N/S Ratio	E Total N Excreted	E N/S Ratio	Y Total N Excreted	Y N/S Ratio
	(mg.)		(mg.)		(mg.)	
27	5900.0	14.67	6936.0	15.78	6692.0	15.44
28	6311.0	14.95	6862.0	14.84	6960.0	15.17
29	6289.0	14.69	6694.0	13.93	6705.0	14.82
Av.		14.77		14.85		15.14
30	6211.0	14.99	6684.0	15.12	6936.0	14.92
31	6170.0	15.10	6826.0	15.15	6984.0	14.37
32	6216.0	14.73	6940.0	15.42	7216.0	15.15
33	6114.0	14.17	6803.0	15.16	6783.0	14.70
34	6241.0	14.67	6853.0	14.78	———	———
Av.		14.73		15.13		14.79

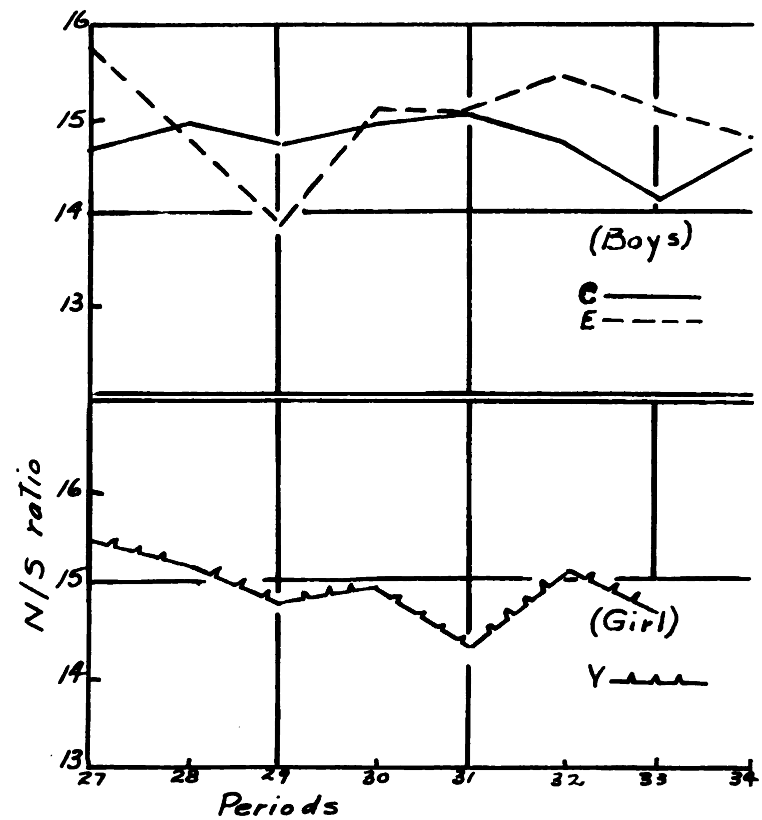
TABLE 27

RANGE IN N/S RATIOS ON
HIGH SUGAR DIET

Child	Highest Ratio	Lowest Ratio	Range
C	15.10	14.17	0.93
E	15.42	14.78	0.64
Y	15.15	14.37	0.78

Chart 20.

N/S RATIO ON HIGH SUGAR DIET



SUMMARY

This study was made to determine the effect of additional calories in the form of fat, starch, and sugar on the urinary sulfur excretion of six preschool children. The experimental period lasted 102 days with a preliminary adjustment period of 14 days. The entire study included determinations on other minerals.

1. During each diet the total sulfur excretions varied in proportion to the dietary intake--the children who had the larger intakes had greater sulfur excretions.

2. The per kilogram sulfur excretions also varied in proportion to the dietary intake.

3. Additional calories in the form of fat, starch, and sugar had no effect on the per kilogram urinary sulfur.

4. In general, there was a negative correlation between the percentage gain in weight and percentage of dietary sulfur excreted in the urine. The lower percentage gain in weight was accompanied by a higher percentage excretion of urinary sulfur.

5. The girls made greater percentage gains in weight than did the boys on each of the diets.

6. All of the children made the greatest percentage gains on the high fat diet and the least on the basal diet.

7. The additional calories decreased the N/S ratio in all cases.

8. All of the children excreted a higher percentage of their calculated dietary sulfur on the basal than any of the other three diets.

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