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AGRICULTURAL EXPERIMENT STATION

RESEARCH BULLETIN 125

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The authors wish to express their appreciation for the intelligent and enthusiastic cooperation of the seventy young women who served as subjects for this study.

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One Hundred Studies of the Calcium, Phosphorus, Iron, and Nitrogen Metabolism and Requirement of Young Women[1]

RUTH M. LEVERTON and ALICE G. MARSH

The period between 16 and 25 years of age may be viewed as a nutritionally crucial one, especially for women. During these years a good nutritional status acquired in childhood can be strengthened and built upon or can be lowered to the vanishing point by ignorance or carelessness in food habits alone. If poor food habits are coupled with the stress of pregnancy and lactation, nutritional status will suffer still more. On the other hand, during these years before certain growth impulses subside there is still the chance of improving to a marked degree a poor nutritional status and paving the way for continued improvement during adulthood. The nutritional requirements of this age group are therefore of paramount importance, whether for meeting normal needs or for overcoming previous deficiencies, but complete metabolism data from which to determine the requirements for girls and women of this age are meager.

The present study was undertaken to add appreciably to the data available on the metabolism of calcium, phosphorus, iron, copper, and nitrogen of young women on their customary self-chosen diets. It was planned to use the figures for the retentions or losses of these dietary essentials which occurred at various levels of intake to determine the requirement of the subjects and to evaluate the adequacy of present adult dietary standards for young women.

The fact that the girls were living on self-chosen diets warrants emphasis. A large proportion of the subjects were doing light housekeeping and brought much of their food supply with them from their rural homes. It is likely that their dietary practices at the university were similar to those they had followed during previous years at home and that they were adhering to their customary pattern of food habits even though cost might have modified these habits somewhat. This group offered an opportunity to study the dietary practices which had been developed during childhood and which may have had a relation to their present nutritional status.

REVIEW OF LITERATURE

There are numerous reports in the literature of studies of the calcium, phosphorus, iron, and nitrogen metabolism of women, and most of the subjects are reported as "young" although the actual age is seldom given. The purpose of most of these studies was to determine the availability of the calcium, phosphorus, and nitrogen from various food sources. Although this purpose differed from that of the present study—that is, the study of metabolism on freely chosen diets—the results of both are comparable from the standpoint of metabolic performance at different levels of intake. It is generally recognized that previous nutritional history and body stores, together with the size of intake during the period of study, probably cause greater variation in metabolism than the specific food source of the nutrient.

[1] Approved for publication by the Advisory Committee as paper No. 10 of the Regional Project of the North Central States Relating to the Nutritional Status of College Women.

The studies which were reviewed and are summarized here do not constitute an exhaustive list but rather were selected as those most nearly comparable to the present study. Only those were included which were done on normal women, were at least three days in length, and in which all the metabolism figures were determined by analysis. Whenever there were groups of consecutive days with the same diet, and these were divided into periods, the average figures for the entire time were used.

In order to facilitate handling the many figures from the metabolism studies of individual subjects selected from the literature, and in order to present concisely the features pertinent to the study being reported, the individual subjects having similar intakes of the same nutrient were arranged in six or seven groups. The divisions into different groups are somewhat arbitrary, but were chosen to correspond to similar groups used in the present study. Six groups were made for calcium, phosphorus, and iron, and one of the middle groups closely approached the value of the present standard dietary allowances; seven groups were made for nitrogen because there were some extremely low intakes. The range of intakes of each nutrient for the different groups is given in Table 1. Most of the studies from the literature fall into the lower-intake groups because they were planned to provide only enough of the nutrients needed to maintain equilibrium.

TABLE 1.—*Range of intakes of each nutrient assigned to the groups into which subjects selected from the literature were placed.*

Group	Calcium	Phosphorus	Iron	Nitrogen
	g.	*g.*	*mg.*	*g.*
00	......	......	......	Less than 5.60
0	Less than 0.400	Less than 0.600	Less than 5.94	5.60– 6.89
1	0.400–0.599	0.600–0.849	5.94– 7.99	6.90– 8.19
2	0.600–0.799	0.850–1.099	8.00– 9.99	8.20– 9.49
3	0.800–0.999	1.100–1.349	10.00–11.99	9.50–10.79
4	1.000–1.199	1.350–1.599	12.00–13.99	10.80–12.09
5	More than 1.199	More than 1.599	More than 13.99	More than 12.09

The figures from the studies of calcium metabolism that were chosen from the literature represent 194 metabolism periods on 86 different individuals from 21 reports *(1, 3, 4, 5, 6, 7, 8, 12, 13, 18, 19, 20, 21, 23, 25, 26, 28, 29, 30, 31, 32)*.[2] The daily intakes range from 0.08 to 1.078 g. and retentions from –0.370 to 0.312g., and Table 2 shows the results when the individual studies with similar intakes are grouped together as explained earlier. The discussion of as heterogeneous a group of results as reviewed here yields little but generalities, except that the results illustrate the long recognized relationship of the size of intake of calcium to the amount of calcium retained.

Since there were only 15 of 86 subjects with intakes of calcium above 0.6 g. daily and the nature of the diets differed greatly, it is inadvisable to generalize further than to say that daily intakes of 0.490 g. or less of calcium were seldom sufficient to maintain equilibrium and that intakes above 0.705 g. were sufficient in most cases.

[2] Numbers in parentheses refer to literature cited.

A summary of the results of the studies of phosphorus metabolism that were selected from the literature are given in Table 3. There were 66 metabolism periods on 32 different individuals from eight reports in the literature *(3, 8, 12, 21, 25, 29, 30, 31)*. The daily intakes ranged from 0.337 to 1.246 g., retentions from –0.59 to 0.40 g.

TABLE 2.—*Summary of calcium metabolism figures from the literature.*

Group	Range of intake	No. subjects [1]	No. metabolism periods	Average daily		Per cent in negative balance
				Intake	Retention	
	g.			*g.*	*g.*	%
0	Less than 0.400	41	84	0.303	–0.075	82
1	0.400–0.599	43	94	1.490	–0.021	46
2	0.600–0.799	10	11	0.705	0.089	18
3	0.800–0.999	1	1	0.820	0.069	0
4	1.000–1.199	4	4	1.057	0.087	0
5	More than 1.199	0	0	....	....	..

[1] Some individuals were studied at more than one level of intake.

TABLE 3.—*Summary of phosphorus metabolism figures from the literature.*

Group	Range of intake	No. subjects [1]	No. metabolism periods	Average daily		Per cent in negative balance
				Intake	Retention	
	g.			*g.*	*g.*	%
0	Less than 0.600	12	25	0.449	–0.056	52
1	0.600–0.849	13	25	0.707	–0.051	39
2	0.850–1.099	5	5	0.922	–0.080	40
3	1.100–1.349	10	11	1.166	–0.001	18
4	1.350–1.599	0	0	....	....	..
5	More than 1.599	0	0	....	....	..

[1] Some individuals were studied at more than one level of intake.

Nearly all of the diets were planned on very low levels of phosphorus intake, and none was as high as the present standard allowance for adults. With very few exceptions all of the studies show a negative or very slight retention. The general picture, however, is similar to other series of metabolism figures in that the negative balances decrease as the size of the intake increases. When the individual studies are grouped according to intake as shown in Table 3, the average figures for all groups show no retentions.

The literature on iron metabolism of normal women is not extensive and does not record many different subjects. The data in Table 4 summarize the results of studies of 13 subjects and 31 metabolism periods from six reports *(9, 14, 17, 22, 24, 35)* and show the relation of intake to the retention. The daily intakes range from 3.06 to 14.16 mg. and the retentions from –2.29 to 4.23 mg. The ten subjects with an average daily iron intake of 6.76 mg. had an average retention of 1.16 mg., which is sufficient storage to cover normal menstrual losses. The relatively recent concept that the body controls its iron stores by absorption or lack of absorption rather than by excretion means

TABLE 4.—*Summary of iron metabolism figures from the literature.*

Group	Range of intake	No. subjects [1]	No. metabolism periods	Average daily		Per cent in negative balance
				Intake	Retention	
	g.			*g.*	*g.*	%
0	Less than 5.94	5	9	3.86	0.14	11
1	5.94– 7.99	7	10	6.76	1.16	10
2	8.00– 9.99	3	3	9.02	2.38	0
3	10.00–11.99	3	3	11.20	0.66	0
4	12.00–13.99	4	5	13.25	–0.008	40
5	14.00–16.71	1	1	14.16	–0.90	0

[1] Some individuals were studied at more than one level of intake.

that so-called negative balances result from atypical metabolism periods rather than from actual loss of iron from the tissues. The number of cases at any particular level of iron intake is too small to warrant generalizations concerning the relation of intake to retention.

Data from the studies of nitrogen metabolism chosen from the literature are summarized in Table 5. This includes the results of 51 metabolism periods on 27 individuals reported in ten studies *(1, 3, 24, 25, 27, 28, 29, 30, 31, 32).* The daily intakes of nitrogen ranged from 4.00 to 12.75 g. and retentions ranged from –2.67 to 1.34 g. of nitrogen per day.

TABLE 5.—*Summary of nitrogen metabolism figures from the literature.*

Group	Range of intake	No. subjects [1]	No. metabolism periods	Average daily		Per cent in negative balance
				Intake	Retention	
	g.			*g.*	*g.*	%
00	Less than 5.60	15	25	4.80	–0.28	36
0	5.60– 6.89	6	8	6.24	–0.45	50
1	6.90– 8.19	5	6	7.34	–0.27	50
2	8.20– 9.49	1	1	8.98	1.34	0
3	9.50–10.79	5	6	10.13	–0.13	33
4	10.80–12.09	2	3	11.33	0.14	0
5	More than 12.09	2	2	12.67	1.02	0

[1] Some individuals were studied at more than one level of intake.

Although there were only 1, 3, and 2 metabolism periods reported in Groups 2, 4, and 5, respectively, the tendency toward greater retention on higher intakes is shown in the case of nitrogen as it is for the minerals.

On the basis of the studies reviewed here, and other data, recommendations have been made for the amounts of these dietary essentials that would meet "minimal requirements" or provide "optimal allowances." Dietary practices, however, often do not coincide with the recommendations made for them. This has been observed particularly among college women enrolled in home economics departments, probably because the students are frequently required to keep records of food consumption and because staff members are constantly alert to discrepancies between the acquisition of knowledge and its application to everyday living.

Questions that arose concerning the significance of existing dietary practices led a group of nutrition research workers and teachers to plan to study intensively the college girl's dietary practices and her nutritional state. During 1935 and 1936 a regional cooperative project was set up in the Home Economics subsections of the Experiment Stations in Iowa, Kansas, Minnesota, Nebraska, Ohio, and Wisconsin, and later in Oklahoma. The title of the master project was "The Nutritional Status of College Women as Related to Their Dietary Practices." The main phases to be studied were anthropometric measurements, basal metabolism, formed elements of the blood, dietary studies, and dietary balances or metabolism studies.

The work at the Nebraska Station has dealt almost entirely with metabolism studies and the general results have been pooled with those of the other cooperators for a joint publication. Since the Nebraska studies totaled one hundred and there was a considerable amount of valuable and interesting material that could not be presented in a summary article of the length designed for scientific periodicals, this material is presented in a research bulletin.

PROCEDURE

One hundred metabolism studies which included the analysis of aliquot samples of the food intake and the fecal and urinary excretion for periods of one week were made on 70 healthy college women between the ages of 16 and 27 years. From the fall of 1937 until the spring of 1940, 53 women were studied once, 7 twice, 7 three times, and 3 four times.

Seventy-one of the studies were made when the subjects were doing light-housekeeping, 22 while living at home, and 7 while eating at a cafeteria. In all cases the usual habits of eating were being continued.

Each subject was in normal health as judged by (1) a general routine medical examination, (2) an evaluation of her health history, and (3) a critical inspection by the research worker during the week of study. Subjects were not studied during menstruation or when they were suffering from colds.

All servings of food and beverages were weighed on Hanson dietetic scales and the weight was recorded to the nearest gram. The assembling, weighing, and recording of all meals were closely supervised to insure accuracy in the subsequent sampling. The research worker was especially careful not to influence the selection or preparation of food, the amount eaten, the time of meal, or the attitudes toward foods during the study.

Each subject was trained to weigh her food accurately and to keep careful records so that she was not dependent upon the presence of a research worker in case of between-meal eating or in an emergency. She was also instructed to prepare throughout the week approximately one-fifth more food than was her custom. In this way samples of food saved for analysis did not decrease her usual intake of food. At the time the meal was served, a sample of each food was stored in a glass screw-top jar and taken to the laboratory for analysis.

Water consumed away from home was measured in calibrated folding cups and food eaten off the campus consisted largely of candy bars of standard weight and bottled beverages. A small purse notebook and pencil were provided and the subject thus kept a record of all food and water taken when away from home.

Every 24 hours a composite sample consisting of one-tenth of the total intake of food was weighed to the nearest 0.1 gram on a trip balance. The sampling was made directly from the small storage jars into a Pyrex beaker. An amount equivalent to one-tenth of all the water drunk was added to the food composite.

The week's food composites were made into smooth brown digests by heating with 20 per cent hydrochloric acid, and then the digests were made to a known volume and stored until time was available for analyzing them.

The period during which all fecal material was saved for analysis was marked by carmine given in gelatin capsules at the first breakfast of the observation week and again before the first breakfast following its close. Fecal collections during the early studies were made directly into Pyrex one-liter beakers which were cut down to a height of four inches. These were covered with filter paper and placed in covered aluminum pans for transportation. Later it was found more convenient and just as accurate to use round 12-ounce cottage cheese cartons lined with small cellophane sacks. The cardboard covers were fitted tightly on the boxes for temporary storage, and for transportation they were placed inside one-pound coffee tins painted inside and out to prevent rust.

Each subject's feces during the week of study were transferred into a two-liter beaker and acidified with 20 per cent hydrochloric acid. This was heated to form a smooth brown digest which was made to a known volume and stored.

Each 24-hour collection of urine during the week was made under toluol in a two-liter glass-stoppered bottle. For some subjects it was more convenient to use one-quart Mason jars with glass tops. The equipment necessary for these collections was provided in the girls' homes and at convenient stations on the campus. Sixteen-ounce screw-top glass jars that fitted into neat boxes were provided for those who were away from the campus for any length of time and needed to make urine collections. A urine composite for the week was made by combining one-tenth of the day's collection in a glass-stoppered storage bottle and acidifying it with hydrochloric acid.

Triplicate samples of each of the biological materials—the acidified urine composites, the brown digests of the food composites, and those of the fecal composites—were used for nitrogen determinations. For mineral analysis another set of samples was oxidized by the method previously described *(14)*.

Total nitrogen was determined by the Arnold-Gunning Macro-Kjeldahl method *(2)* using $CuSO_4$ as a catalyst.

Calcium was precipitated as the oxalate from the ash solution and titrated with potassium permanganate using the McCrudden method modified as described by Stearns *(33)*.

Phosphorus was determined colorimetrically by the method of Fiske and Subbarow *(10)* using alpha-aminonaphthosulfonic acid as a reducing agent.

Iron as the thiocyanate was determined in the ash solution by the method developed by Stugart *(34)*.

A visual colorimeter was used for the phosphorus and iron determination for the first 13 subjects. Thereafter a Sanford-Sheard photelometer was used. This was calibrated with solutions of known concentrations, and a table of photelometer readings and corresponding concentrations was made.

The laboratory, equipped with an air filter and conditioner, was especially built to prevent contamination of the materials with iron. Great care was maintained throughout the experiment to avoid contamination of the biological materials. Dust was considered a very serious source of contamination; so all materials were carefully protected from any continued exposure and strict vigil was kept to avoid rust, especially during the times many hydrochloric acid digests were being made.

The management of so large a number of subjects over a period of three years warrants more than casual comment. Only those young women are reported as subjects who gave excellent cooperation throughout the study. It was necessary to omit an occasional subject when there was reason to believe that the records or collection had not been complete or if the week of study had developed into an atypical one for the subject. Sufficient instruction and detailed training were given before the balance study began so that the newness and strangeness of the regimen was not a complicating factor. The subjects were happy, interested, and unannoyed. Each one was told that the study to be made on her was not one of correct or incorrect dietary practices but rather of how much of the food she ordinarily ate was stored in her body; thus she realized that the success of the study depended primarily upon her continuing her usual dietary and living habits. Her accuracy, dependability, and cooperation were solicited, but she was also encouraged to live in her usual manner as casually as possible.

While the students were serving as subjects, they were able to attend the social activities that occurred under ordinary circumstances. At such times one of the workers arranged to be in the serving room where she could weigh the food that was to be served to the subject and take samples for analysis. Thus the subject ate the same food that was served to all. On "dates" she was confined to bottled beverages and candy bars of standard weight for refreshments. Guest dinners in private homes and in institutions off the campus were hard to manage, and since they were not frequent the students were advised to choose a week to be studied when they did not expect such activities.

The workers received real satisfaction from the favorable reactions of the subjects toward the study. This gratifying situation was attributed to several factors. In the first place a student considered it a privilege to be asked to be a subject. An aura of superiority surrounded those who were selected because only students who had proved themselves to be cooperative and intelligent and were in a good state of health were chosen. Second, the "privilege" aspect alone was not relied upon as the only method for securing good cooperation. Each girl was paid two dollars for one week of study, together with reimbursement for the cost of the extra food used for sampling. This amount was sufficient to pay amply for the little time and small inconvenience the study required of her.

In every way possible the bulk of the work and responsibility was placed on the research workers. The subjects were not burdened in any way, but rather many of the girls enjoyed the attention given them and considered the study an educational experience.

RESULTS

Because one of the greatest values of these results lies in the number of subjects and, therefore, the cross-section of metabolic activity that is represented for young women of this age, it is the plan to emphasize average figures of all subjects and of groups of subjects more than individual studies. Data on the individual studies are given in the Appendix. These include the height, weight, and age of each girl as well as the metabolism figures. The intake, excretion, and retention of calcium, phosphorus, iron, and nitrogen for each subject are expressed in terms of the average daily amount of each of the four nutrients and also in terms of milligrams of calcium per centimeter of height, and milligrams of phosphorus, iron, and nitrogen per kilogram of body weight per day.

Averages for the daily intake, excretion, and retention of calcium, phosphorus, iron, and nitrogen for the entire group are given in Table 6, while in Table 7 are given the averages for the daily intake and retention of calcium per centimeter and of phosphorus, iron, and nitrogen per kilogram. In no instance did the level of these intakes fail to cover the excretion. With calcium and phosphorus there was a state of equilibrium, and with iron and nitrogen there was some storage.

TABLE 6.—*Average daily intake, execretion, and retention of calcium, phosphorus, iron, and nitrogen for all subjects.*

Nutrient	Intake	Coefficient of variation	Urine	Feces	Total	Coefficient of variation	Retention
Calcium (*g.*)	0.857±.017	29.7	0.161	0.683	0.844±.016	28.5	0.013±.011
Phosphorus (*g.*)	1.088±.016	21.8	0.609	0.446	1.055±.013	18.9	0.033±.013
Iron (*mg.*)	10.44 ±.160	22.6	....	....	9.07 ±.137	22.2	1.37 ±.012
Nitrogen (*g.*)	9.46 ±.106	16.7	7.72	1.16	8.88 ±.075	12.5	0.58 ±.073

TABLE 7.—*Average daily intake and retention of calcium per centimeter of height and of phosphorus, iron, and nitrogen per kilogram of weight for all subjects.*

Nutrient	Intake	Retention
	mg.	*mg.*
Calcium per cm.	5.25	0.09
Phosphorus per kg.	19.44	0.58
Iron per kg.	0.186	0.024
Nitrogen per kg.	169.40	10.70

Since the level of the excretion of a nutrient follows in general its level of intake, variations in excretion would tend to follow those in intake. Another factor, however, that contributes to the variability of excretion is the path of excretion of the nutrient. For instance, in the case of nitrogen seven-eighths of the total nitrogen excreted is in the urine, but in the case of calcium three-fourths of the total calcium excreted is in the feces. Much of the variation could be due to errors inherent in the method of study. Almost everyone who has had experience with the mechanics of metabolism studies has had occasion to lament the shortcomings of giving carmine to mark the feces, having the carmine at the mercy of any and all of the fluctuations in gastric motility, and then having part of the analytical results dependent upon the accurate separation of the marked from the unmarked portion of the stools.

In order to analyze differences and still deal with groups of subjects rather than with individual cases all of the metabolism data for each of the nutrients calcium, phosphorus, iron, and nitrogen have been sorted into groups according to the level of intake of each nutrient. In this way it is possible to compare the excretion and retention of different groups of subjects at progressively greater intakes of calcium, phosphorus, iron, and nitrogen. The intake of each nutrient is shown in terms of both total per day and per centimeter of height for calcium and per kilogram of body weight for the other three nutrients. The groupings were made rather arbitrarily within the range of intakes represented by the individual studies. Five groups were made and the third or middle was chosen so that it would closely approach the value of the standard dietary allowance for that nutrient. The results of this treatment of the data are given in Tables 8 and 9, which show for each intake group the number of studies, the average daily intake, excretion, and retention or loss found for the subjects within that group, and the percentage of studies in each group that showed negative balances. The columns to be emphasized are those labeled "Retention" and "Per cent in negative balance." As is to be expected in the case of every nutrient, the least retention or the largest negative balance occurred on the lowest intakes, and as the intakes rose the occurrence of negative balances decreased until they finally disappeared, and the size of the retentions increased.

Because the influence of size on dietary requirements is to be expected, it seems logical to express results such as these on the basis of the unit of height or weight and thus eliminate size as a factor. Although the resulting figures may be a little more cumbersome than a single figure designed to be applied to all individuals within certain broad limits, they do offer a means of adapting general recommendations to individual requirements.

The average height and weight of groups of subjects with the lowest average daily intake of each nutrient is lower than for the groups with the next larger intake, and that average in turn is lower than the one for the groups with a still higher intake. In other words, it might appear that the smaller girls ate less food and thus had smaller intakes of calcium, phosphorus, and iron. (In the case of nitrogen there were no increases in weight with each increase in intake as there were with height.) Also within the group with the lowest intakes of calcium (0.421 to 0.599 g.) the average height of the 13 subjects in negative balance was 4.5 centimeters greater than the average height of the five subjects in positive balance. However, the fact that there were many more negative balances at the lower levels of intake than at the higher ones shows that even though the lower intakes were taken by the smaller girls, the difference in the average body size between them and the larger girls was not enough to make the lower intakes adequate for the smaller girls. This means that the higher intakes of the different nutrients were not attributable solely to larger total food consumption but rather reflected habits of food choice. This is further borne out in records of individual subjects. For example, the ten individuals who had the largest calcium retentions per centimeter per day were the same ten individuals who had the largest calcium retentions on the basis of the total daily amount per day. The ten who had the largest negative balances per centimeter per day with one exception were the same ten who had the largest total negative balances and the same relationship held for the other nutrients.

Differences in size among girls of this age cannot, therefore, be depended upon to reduce requirements to the extent of counterbalancing inadequacies whether they were caused by small total food consumption or poor food selection, or both. This does not mean that size has no influence on requirement but rather that in a sampling of young women such as was made for this study nutritional background probably had so much more influence that the size factor was overshadowed.

It makes little difference then in this report whether results are expressed as figures for total daily metabolism or for metabolism per unit of size.

There was no indication that age was an influencing factor in these metabolism results. When the subjects were divided into groups according to age any differences in metabolism performance were directly attributable to differences in the size of the intake rather than to differences in age. The results for the 61 subjects under 21 years were very similar to those for the subjects above 21 years.

Calcium

The figures on calcium metabolism for the subjects show great variability. Considering first the total average daily intakes, these ranged from 0.421 to 1.679 g. and the retentions from –0.463 to 0.377 g. The average daily values for the intake, excretion, and retention of the 98 studies (two were considered atypical and therefore omitted) were 0.857, 0.842, and 0.015 g., respectively.

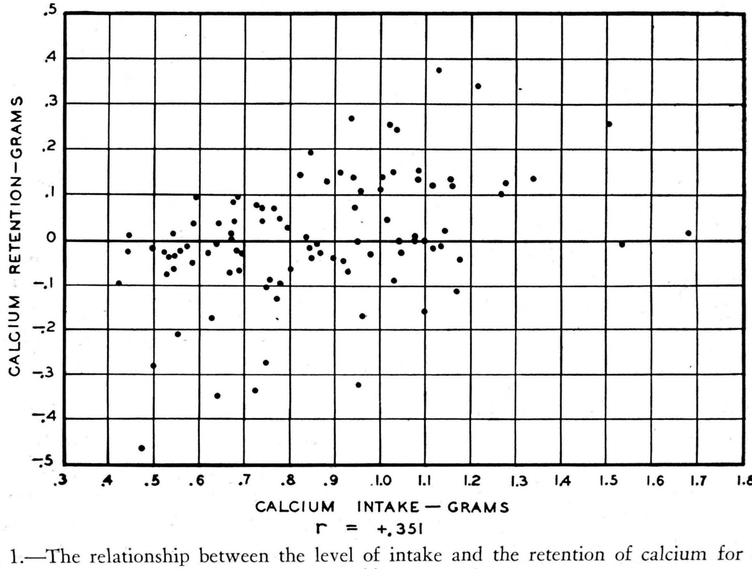

FIG. 1.—The relationship between the level of intake and the retention of calcium for each subject.

The distribution of individual studies into different intake groups as presented in Table 8 shows that one-fourth of the studies were in each of the three intake groups, 0.6 to 0.799 g., 0.8 to 0.999 g., and 1.0 to 1.199 g., or three-fourths of the intakes were between 0.6 and 1.199 g. There were two and one-half times as many intakes below 0.6 g. as there were above 1.199 g.

Both the extent of negative balances and the frequency with which they occurred were greatest at intakes between 0.421 and 0.599 g. per day; 61 per cent of the subjects in this group were in negative balance and the average negative balance was –0.068 g. per day. The percentage in negative balance decreased as the intakes increased until at intakes between 1.0 and 1.2 g. only 9 per cent were in negative balance, and the average retention of all the subjects in that group (both those in negative and in positive balance) was 0.089 g. When the daily intakes were above 1.2 g., there were no negative balances but instead an average daily retention of 0.134 g.

The relationship between the level of intake and the retention for each subject is plotted in Figure 1. The amount of calcium that was retained at the different levels of intake increased sharply as the average daily intake rose from 0.523 to 1.083 g. The highest average retention for a group occurred at the highest average intake and this amount also represented the highest percentage of any intake that was retained.

When the intakes of calcium are calculated on the basis of milligrams of calcium per centimeter of height, the values range from 2.49 to 10.17 mg. per day, with an average of 5.25 mg. The retentions varied from –3.01 to 2.32 mg. per centimeter per day and averaged 0.09 mg. The results of placing the subjects into groups according to the size of their intakes per centimeter are shown in Table 9. Here, as with the total daily intakes, the extent and frequency of occurrence of negative balances decreased as the intakes increased.

The group that had an average intake of 4.71 mg. of calcium per centimeter per day had an average retention of –0.02 which may be considered equilibrium and only 25 per cent of the 36 subjects in this group had negative balances greater than 5 per cent of the intake.

Phosphorus

The figures for phosphorus metabolism also show a wide range of intake and retention; the average daily intakes varied from 0.629 to 1.806 g. and the retentions from –0.458 to 0.572 g. The average daily intake, excretion, and retention of the 100 studies were 1.088, 1.055, and 0.033 g., respectively. Table 8 shows that one-third of the studies occurred in each of two intake groups, 0.850 to 1.099 g. and 1.100 to 1.349 g.; or two-thirds of the daily intakes were between 0.850 and 1.349 g. There were 20 intakes below 0.850 g. and 13 above 1.349 g.

All negative retentions occurred at intakes between 0.600 and 1.349 g., or within the three groups with the lowest intakes. In the lowest intake group, 0.600 to 0.849 g., 94 per cent of the subjects were in negative balance; in the second intake group, 0.850 to 1.099 g., 52 per cent were in negative balance; and in the third intake group, 1.100 to 1.349 g., only 10 per cent were in negative balance. When the intakes exceeded 1.272 g., no negative balances occurred. The group which had the greatest loss, –0.184 g. of phosphorus daily, was also the group with the lowest intake; groups with the greatest retentions, 0.212 and 0.211 g., had the largest amounts of phosphorus in the diets.

The relationship between the level of intake and the retention for each subject is shown graphically in Figure 2. There is a rapid and consistent rise in retention (–0.184 g. to 0.212 g.) as the intake increases from a group average daily intake of 0.766 g. of phosphorus to one of 1.430 g.

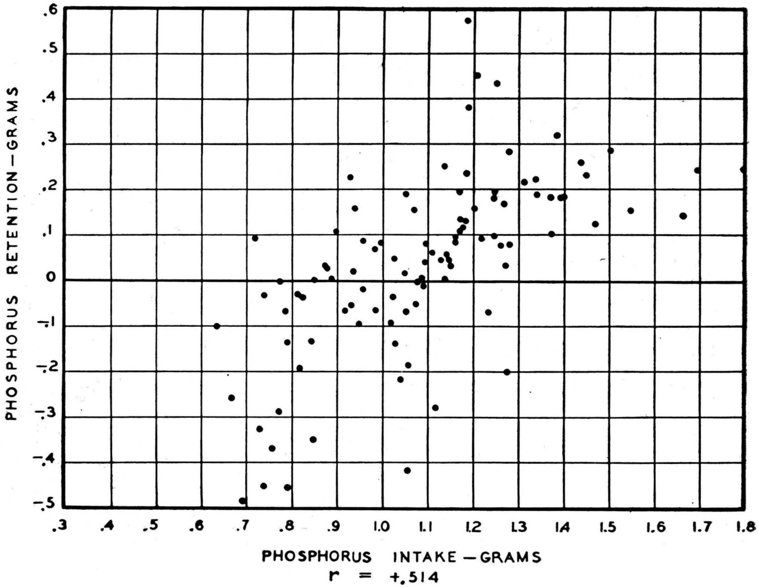

FIG. 2.—The relationship between the level of intake and the retention of phosphorus for each subject.

When the phosphorus intakes are calculated on the basis of milligrams of phosphorus per kilogram of body weight, the figures range from 10.68 to 32.37 mg. per day, with an average of 19.44 mg. The retentions varied from –9.60 to 9.85 mg. per kilogram per day and averaged 0.58 mg.

Iron

With iron it is necessary to have storage to replace the iron lost in the menses; therefore, regardless of the theories of excretion, metabolism results must show positive balances if optimum nutrition in respect to iron is to be maintained.

The average daily intakes of iron ranged from 5.94 to 16.71 mg. and the retentions from –2.12 to 6.50 mg. The average daily values for the intake, excretion, and retention of the 99 studies (one study was omitted because the subject had recently had an "iron tonic") were 10.44, 9.07, and 1.37 mg., respectively. This daily retention compares favorably with the allowance of 1 mg. calculated as sufficient to replace iron lost in the menses *(16)*.

The 99 studies are distributed into five groups according to the size of intake and the results are given in Table 8. It is evident that nearly two-thirds of the daily intakes or a total of 62 studies are between 8.00 and 11.99 mg. In no group did the average of the daily excretions exceed the average of the daily intakes of iron to result in a so-called negative balance. The average storage of the group with the lowest daily intake, 5.94 to 7.99 mg., was not great enough to cover normal menstrual losses, as it was for the other groups. The relation of the intake of iron to its retention is shown in Figure 3.

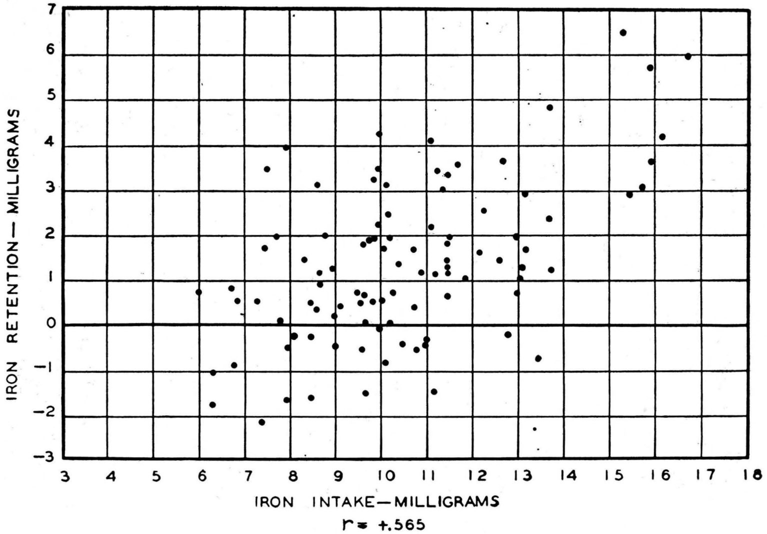

FIG. 3.—The relationship between the level of intake and the retention of iron for each subject.

The intakes of iron calculated on the basis of milligrams of iron per kilogram of weight give a range of values from 0.105 to 0.312 mg. per day with an average of 0.186 mg. When the retentions are calculated on this basis their values vary from −0.037 to 0.112 mg. per day with an average of 0.024 mg.

Previous publications from this laboratory present evidence that dietary essentials other than iron are important factors in preventing or correcting simple anemia in young women. For this reason in Table 10 the diets of all the subjects who were storing iron and the diets of all the subjects in negative balance are compared with respect to iron, calcium, phosphorus, and nitrogen. While these nutrients are not the only ones by which to judge the adequacy of the diets, they are recognized as important objective measures.

Although differences between contents of the diets of the two groups are not highly significant statistically, the consistency with which the differences are always in favor of the group that is storing iron is probably of greater significance than the actual numerical differences.

These numerical differences are greatly accentuated, however, at levels of iron intake below 8 mg. This is shown in Table 11 when the 15 individual

TABLE 8.—*Average metabolism data for calcium, phosphorus, iron, and nitrogen of different groups of subjects arranged according to the level of intake of each of these nutrients.*

Range of daily intake	No. studies	Average daily: Intake	Urine	Feces	Total excretion	Retention	Per cent in negative balance [1]	Group Average: Ht.	Wt.	Age
				CALCIUM (*g.*)						
							%	*cm.*	kg.	*yr.-mo.*
0.400–0.599	18	0.523	0.125	0.465	0.591	–0.068	61	161.3	55.0	19–11
0.600–0.799	26	0.703	0.177	0.561	0.738	–0.035	35	162.5	56.7	21– 3
0.800–0.999	24	0.896	0.159	0.714	0.873	0.023	21	165.3	57.8	21– 4
1.000–1.199	23	1.083	0.159	0.835	0.994	0.089	9	164.1	54.8	20– 0
1.200–1.679	7	1.403	0.194	1.075	1.269	0.134	0	161.9	59.8	20– 8
				PHOSPHORUS (*g.*)						
0.600–0.849	20	0.766	0.552	0.398	0.950	–0.184	94	160.8	54.3	20– 5
0.850–1.099	32	0.998	0.571	0.432	1.003	–0.005	52	163.0	55.2	20– 9
1.100–1.349	35	1.203	0.615	0.459	1.074	0.129	10	164.2	58.6	20– 6
1.350–1.599	10	1.430	0.733	0.495	1.227	0.212	0	165.0	54.4	20– 5
1.600–1.849	3	1.719	0.911	0.597	1.508	0.211	0	159.8	62.4	21– 5
				IRON (*mg.*)						
5.94– 7.99	15	7.16	...	...	6.75	0.41	40	160.8	53.7	20–10
8.00– 9.99	31	9.18	...	...	8.21	0.96	13	162.1	56.0	20– 7
10.00–11.99	31	10.90	...	...	9.53	1.34	6	164.3	56.8	20– 7
12.00–13.99	15	12.91	...	...	11.15	1.77	7	164.8	58.8	21–11
14.00–16.71	7	15.85	...	...	11.30	4.55	0	163.9	58.2	20– 7
				NITROGEN (*g.*)						
5.55– 6.89	5	6.19	6.96	0.98	7.95	–1.75	80	160.3	56.3	20– 2
6.90– 8.19	18	7.59	6.87	1.01	7.90	–0.31	33	160.9	54.2	20– 2
8.20– 9.49	23	8.85	7.29	1.12	8.41	0.43	9	163.7	55.6	21– 2
9.50–10.79	32	10.07	7.83	1.24	9.07	1.01	0	163.9	57.8	20 8
10.80–12.09	19	11.34	8.74	1.22	9.97	1.38	0	162.9	56.5	20– 5
12.10–12.77	3	12.45	9.54	1.36	10.89	1.55	0	167.9	58.7	20– 7

[1] Balances no greater than 5 per cent of the intake were not considered significant and therefore were counted as equilibrium.

studies, in which the daily iron intakes ranged from 5.94 to 7.99 mg., are similarly divided into those storing iron and those not storing it.

These figures of iron intake and balance show the limitations to the value of average figures. The group with intakes between 5.94 and 7.99 mg. (Table 8) did not store enough to cover menstrual losses, but the figures in Table 11 show that those who were storing iron did so to a greater extent than the average for all 99 studies; their average retention was 1.55 mg. as compared with 1.37 mg. for all of the studies.

It would appear then from the differences in the calcium, phosphorus, and nitrogen contents of the diets of the subjects storing iron and those not storing it that when the daily iron intake is below 8 mg. the adequacy of the diet in other nutrients, probably not just those discussed here, may be the deciding factor in stimulating storage for replacement of that lost in menstruation and perhaps for other functions not so clearly understood or measurable. Several years of contact with the girls, and their families if the girls lived at home, leaves no doubt in the minds of the authors as to the general superiority of the

TABLE 9.—*Average metabolism data for calcium per centimeter, and phosphorus, iron, and nitrogen per kilogram of different groups of subjects arranged according to level of intake of each.*

Range of daily intake	Number of studies	Average daily Intake	Average daily Retention	Per cent in negative balance
		CALCIUM *(per cm.)*		
		mg.	*mg.*	
2.49– 3.99	22	3.35	−0.49	59
4.00– 5.49	36	4.71	−0.02	25
5.50– 6.99	30	6.28	0.45	13
7.00– 8.49	7	7.51	0.74	14
8.50	3	9.82	0.50	0
		PHOSPHORUS *(per kg.)*		
10.00–14.99	13	12.97	−3.50	85
15.00–17.99	26	16.51	−0.90	38
18.00–20.99	30	19.39	1.42	20
21.00–24.99	17	22.85	1.89	6
25.00	14	26.86	3.75	0
		IRON *(per kg.)*		
0.100–0.139	13	0.1268	0.0001	46
0.140–0.179	34	0.1611	0.0219	3
0.180–0.219	33	0.1974	0.0219	15
0.220–0.259	13	0.2346	0.0405	8
0.260	6	0.2843	0.0650	0
		NITROGEN *(per kg.)*		
89–129	11	115.43	−16.84	55
130–149	16	141.82	− 1.57	25
150–169	23	160.05	7.06	4
170–189	25	180.11	20.40	4
190–209	13	200.13	21.24	0
210	12	217.63	28.00	0

TABLE 10.—*Comparison of average daily intakes of calcium, phosphorus, and nitrogen for subjects storing iron and for those not storing iron.*[6]

Source of data	Average daily: Intake, iron	Retention, iron	Intake: Calcium	Intake: Phosphorus	Intake: Nitrogen	Hemoglobin per 100 ml.
	mg.	*mg.*	*g.*	*g.*	*g.*	*g.*
74 subjects storing iron	10.84±.189	2.06	0.876±.021	1.120±.019	9.68±.118	13.3
13 subjects not storing iron	8.76±.335	−1.14	0.695±.037	0.893±.028	8.11±.304	12.8
Difference	2.08±.385	. . .	0.181±.043	0.227±.280	1.57±.325	. . .

[6] Twelve subjects were in equilibrium.

TABLE 11.—*Comparison of average daily intakes of calcium, phosphorus, and nitrogen for subjects with daily iron intakes below 8 mg.*

Source of data	Average daily					Hemoglobin per 100 ml.
	Intake, Fe	Retention, Fe	Intake			
			Ca	P	N	
	mg.	*mg.*	*g.*	*g.*	*g.*	*g.*
9 subjects storing iron	7.21	1.547	1.038	1.119	9.704	13.0
6 subjects not storing iron	7.09	-1.303	0.663	0.828	7.250	12.4

TABLE 12.—*Comparison of average daily intakes of iron, calcium, and nitrogen of two subjects.*

Source of data	Age when studied	Average daily				
		Intake, iron	Retention, iron	Intake, calcium	Intake, Nitrogen	
					Total	per kilo
	yr.–mo.	*mg.*	*mg.*	*g.*	*g.*	*g.*
Subject 69o	17—1	7.47	3.47	1.083	9.28	0.180
74o	17—8	7.41	1.75	1.169	11.28	0.221
101o	18—2	5.94	0.77	1.084	9.32	0.182
Average	.....	6.94	2.00	1.112	9.96	0.194
Subject 17i	19—7	7.89	-1.65	0.527	5.89	0.090
31i	20—3	6.29	-1.02	0.440	6.95	0.116
Average	....	7.09	-1.33	0.483	6.42	0.103

food habits and nutritional history of the seven girls who were storing iron at this low level of intake as compared with the five who were not.

This is specifically illustrated by the metabolism figures in Table 12 for two girls during different but successive periods of study when their self-chosen diets contained less than 8 mg. of iron daily. Both girls were living at home and eating meals prepared by their mothers.

One (Subject 69o, 74o, 101o, Appendix Table I), had an unquestionably good dietary history and good food habits. Although she cared little for meat, she ate abundantly of milk and cheese, fruits, and vegetables, and used whole-wheat bread and cereals. The other (Subject 17i, 31i) was not conscious of having poor food habits but rarely had drunk milk, did not care for vegetables, and ate white bread to the practical exclusion of whole-wheat products.

Nitrogen

The individual nitrogen metabolism data for the 100 studies show as great variability as do those of the other nutrients studied. The average daily intakes range from 5.55 to 12.77 g. and the retentions from -3.50 to 2.49 g. The average daily intake, excretion, and retention for the 100 subjects are 9.46, 8.88, and 0.58 g., respectively.

The six groups according to the level of nitrogen intake given in Table 12 show that one-third of the subjects had daily intakes between 9.5 and 10.79 g. and most of the remaining two-thirds of the subjects were quite equally distributed in the other three groups that had daily intakes between 6.9 and 12.09 g. nitrogen. Only five studies made up the group with the lowest average intake.

No negative balances occurred in the three groups with the highest average intakes. In the three groups with the lowest average intakes, 80 per cent of the subjects were in negative balance when the daily intakes were between 5.55 and 6.89 g. nitrogen; 33 per cent when the intakes were 6.9 to 8.19 g. nitrogen; and 9 per cent when the intakes ranged from 8.2 to 9.49 g. nitrogen. The figures for the different groups show a consistent decrease in the size of the average negative balance and an increase in the amount retained as the intakes rose. From the group with the lowest intake to that with the highest the average daily retentions were –1.75, –0.30, 0.43, 1.01, 1.38, and 1.55 g. of nitrogen.

The relationship between the level of intake and the retention for each subject is shown in Figure 4. This shows the consistent increase in retention as the intake increased.

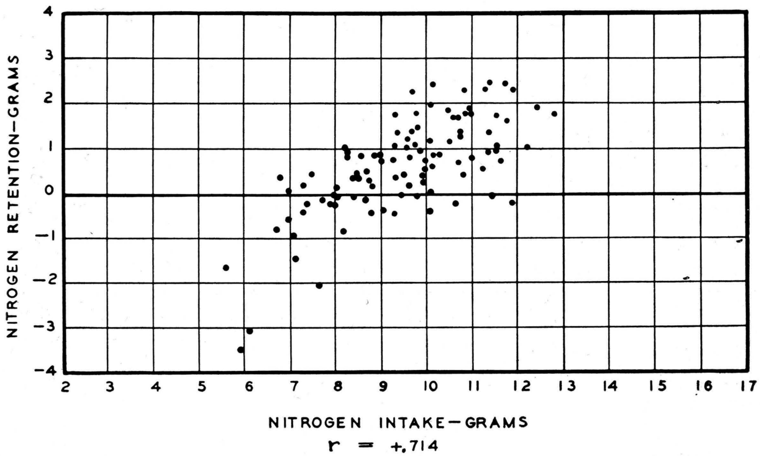

FIG. 4.—The relationship between the level of intake and the retention of nitrogen for each subject.

The intake of nitrogen in milligrams per kilogram of body weight ranged from 89.37 to 235.61 mg. per day and averaged 169.40 mg. The average daily retentions ranged from –65.47 to 44.51 mg. and the average was 10.70 mg. per kilogram.

The percentage of absorption of nitrogen, $\frac{\text{intake–fecal excretion}}{\text{intake}} \times 100$, was calculated for each of the 100 studies and the results are given in Table 13. These values ranged from 78.12 to 94.2 per cent with an average of 87.6 per cent. When the individual values were arranged into the six groups according to the size of intake, the average absorption of nitrogen was 84.1 per cent for the group with the lowest intake and progressed through 86.6, 87.3, 87.7, 89.2 for the next four groups to 89.1 per cent for the group with the highest intake.

The average daily fecal excretion of nitrogen for each group from the one with the lowest intake to the one with the highest was 0.98, 1.02, 1.12, 1.24, 1.22, and 1.36 gm. Since the fecal excretion increased with each increase in intake there was less variation in the per cent of the intake that was absorbed than if the fecal excretion had remained constant irrespective of the intake.

TABLE 13.—*Average daily intake, fecal excretion, and percentage absorption of nitrogen by 100 subjects arranged according to level of intake.*

No. Subjects	Average daily nitrogen		
	Intake	Fecal excretion	Absorption
	g.	*g.*	%
5	6.19	0.98	84.1
18	7.59	1.02	86.6
23	8.85	1.12	87.3
32	10.07	1.24	87.7
19	11.34	1.22	89.2
3	12.45	1.36	89.1
Average	9.46	1.16	87.6

TABLE 14.—*Average daily intake and retention of calcium, phosphorus, iron, and nitrogen of subjects studied more than once.*

Source of data	Average daily							
	Intake, Ca	Retention, Ca	Intake, P	Retention, P	Intake, Fe	Retention, Fe	Intake, N	Retention, N
	g.	*g.*	*g.*	*g.*	*mg.*	*mg.*	*g.*	*g.*
One hundred studies	0.857	0.013	1.088	0.033	10.44	1.37	9.46	0.58
Two studies of 17 subjects:								
First study	0.823	0.061	1.102	0.081	10.78	0.77	9.35	0.57
Second study	0.802	0.053	1.049	0.015	10.30	1.61	8.85	0.15
Three studies of 10 subjects:								
First study	0.825	0.054	1.061	0.060	10.29	0.56	9.17	0.25
Second study	0.844	0.079	1.092	0.053	10.17	1.91	9.05	0.17
Third study	0.861	–0.026	0.979	–0.104	9.08	0.56	9.15	0.72
Four studies of 3 subjects:								
First study	0.922	0.136	1.123	0.110	12.11	2.25	9.85	0.96
Second study	1.015	0.171	1.238	0.140	11.79	3.01	9.48	1.02
Third study	0.953	–0.012	1.099	–0.006	8.36	1.09	10.03	1.06
Fourth study	0.970	0.094	1.176	0.139	9.56	2.80	9.85	0.97

"Repeat" Subjects

Seventeen subjects were studied more than once, but a "repeat" study on a subject was always done at least six months after the preceding one. Of these 17 subjects, 7 were studied twice; 7, three times; and 3, four times. The figures for the intake and retention of the four nutrients each time a subject was studied are given in the Appendix, Table III. The summary of the results of the first study together with those of each additional study is given in Table 14. When the figures for the intake and retention of calcium, phosphorus, iron, and nitrogen for the first study are compared with those of the succeeding ones and when figures for second, third, or fourth studies are compared with the averages for the one hundred studies, there are no consistent trends or differences in the results. It has been shown in a larger series of studies[3] that intra-individual variation is less than inter-individual variation. A gross inspection of Appendix Table III bears this out, especially for those subjects studied three or four times. Although there was an occasional substantial variation in intake (as for instance, the girl who was Subject 11g, 23g, and 70g had calcium intakes at the three different times of 0.625, 0.643, and 1.068 g.) more usual were figures such as those for Subject 17i, 31i, 68i, which were 0.527, 0.440, and 0.421 g.; or for Subject 12h, 18h, 26h, 62h, which were 1.015, 1.027, 1.160, and 1.157 g. In general the subjects with low intakes continued to have low intakes and those with high intakes continued to have high ones. Thus it appears that a first or single observation period under the conditions of careful selection and supervision as described in the "Procedure" can be counted upon to give a typical picture of an individual's self-chosen intake with respect to calcium, phosphorus, iron, and nitrogen.

Retention

In any study of this kind where the results may be used as a basis for determining requirement, considerable interest centers on the relation between increases in intake and subsequent increases in retention. Expression of this relationship is somewhat involved, for it is not the percentage of the intake which is retained but the percentage of the *increase* in intake which is retained that may give the pertinent information. In Table 15 are shown the increases in both intake and retention from the average of a group at one level of intake to the average of a group at the next higher level of intake (the groupings according to intake are the same as those in Table 8). The most significant column is that which shows the percentage of each additional intake that was retained. This was calculated according to the formula:

$$\frac{\textit{retention at higher level—retention at a lower level}}{\textit{intake at higher level—intake at lower level}} \; x\ 100$$

Kinsman and co-workers *(11)* call the figure that results "per cent utilization." Because this term could be misleading in its implication that there is no utilization of calcium unless there is actual storage or that use of calcium for maintenance is not "utilization," in the present report the figure is referred to as the "per cent of increase retained."

In the case of calcium there was a retention of only 18.3 per cent or 0.033 g. of the additional calcium when the intake was increased from 0.523 to 0.703 g. but when the daily intake increased from 0.896 to 1.083 g., 35.3 per cent or 0.066 g. of increase was retained. When the intake increased further, however,

[3] Unpublished data from the Regional Project of the North Central States relating to the Nutritional Status of College Women.

TABLE 15.—*Relationship of increases in level of intake to increases in level of retention for calcium, phosphorus, iron, and nitrogen.*

Nutrient	Increase in average daily intake			Increase in average daily retention			Per cent of increase retained
	From	To	Actual	From	To	Actual	
Calcium (*g.*)	0.523	0.703	0.180	−0.068	−0.035	0.033	18.3
	0.703	0.896	0.193	−0.035	0.023	0.058	30.0
	0.896	1.083	0.187	0.023	0.098	0.066	35.3
	1.083	1.403	0.320	0.089	0.134	0.045	14.1
Phosphorus (*g.*)	0.766	0.998	0.232	−0.184	−0.005	0.179	77.1
	0.998	1.203	0.205	−0.005	0.129	0.134	65.4
	1.203	1.430	0.227	0.129	0.212	0.083	36.6
	1.430	1.719	0.289	0.212	0.211	−0.001	. . .
Iron (*mg.*)	7.16	9.18	2.02	0.41	0.97	0.56	27.7
	9.18	10.87	1.69	0.97	1.34	0.37	21.9
	10.87	12.91	2.04	1.34	1.76	0.42	20.6
	12.91	15.85	2.94	1.76	4.55	2.79	94.9
Nitrogen (*g.*)	6.19	7.59	1.40	−1.75	−0.31	21.0	102.9
	7.59	8.85	1.26	−0.31	0.43	15.7	58.7
	8.85	10.07	1.05	0.43	1.01	11.6	55.2
	10.07	11.34	1.27	1.01	1.38	12.6	29.1
	11.34	12.45	1.11	1.38	1.55	9.8	15.3

to 1.403 g. of calcium per day only 14.1 per cent of the additional calcium was retained.

The figures for phosphorus and nitrogen are similar to each other in trend. The highest percentage retention of any increases in intake occurred at relatively low levels of intake (77.1 per cent of the increase from 0.776 to 0.998 g. of phosphorus and 102.9 per cent retention of the nitrogen increase from 6.19 to 7.59 g.).

The trend of the figures for iron is similar to those of phosphorus and nitrogen except that the seven studies constituting the group with the highest intake showed an average retention of 94.9 per cent of the increased intake over the group with the next lower intake. This percentage of retention was much higher than for the other three nutrients at high levels of intake. The relation between increases in intake and the percentage of the increase that was retained is shown graphically in Figure 5.

The foregoing treatment of the data suggests that the level of intake influenced the amount that was retained when the intake was increased. For instance, when the average daily phosphorus intake increased 0.232 g. (from 0.766 to 0.998 g.) 77.1 per cent of the increase was retained, but when approximately this same increase occurred from 1.203 to 1.430 g. there was a retention of only 36.6 per cent of the increase. The lag exhibited by the calcium figures (that is, only 18 per cent of the increased intake being retained as the intake rose from 0.523 to 0.703 g. but 35 per cent being retained when the intake rose from 0.896 to 1.083 g.) might suggest that increasing daily calcium intakes to 0.703 was not enough to permit significant storage because most of the increase had to be used for maintenance, but when the intake reached 0.896 g.

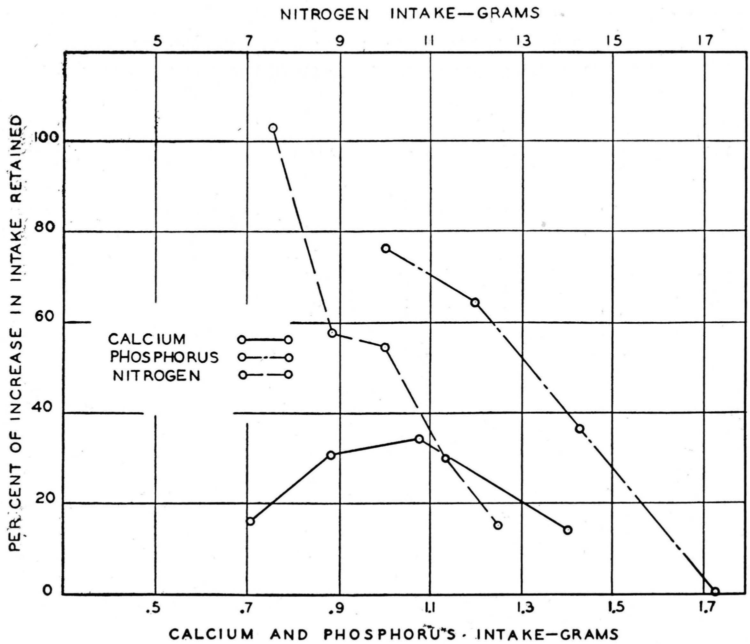

FIG. 5.—The relationship between increases in intake and the percentage of the increased intake that was retained by groups of subjects at different levels of intake of calcium, phosphorus, and nitrogen.

perhaps maintenance needs were being met and then a large portion of any additional amounts might have been available for storage.

Another and simpler way to show the relation between intake of a nutrient and its retention is to express the retention as a percentage of the total intake. Figures for this are as follows:

	Average daily *Intake*	*Per cent retained*		Average daily *Intake*	*Per cent retained*
Calcium (*g.*)	0.523	−13.0	Phosphorus (*g.*)	0.766	−24.0
	0.703	− 5.0		0.998	− 5.0
	0.896	2.8		1.203	10.7
	1.083	8.2		1.430	14.8
	1.403	9.0		1.719	12.3

Nitrogen (*g.*)	6.19	−28.3
	7.59	− 4.1
	8.85	4.9
	10.07	10.0
	11.34	12.2
	12.45	12.4

These results are charted in Figure 6 to show the rather steep curves made by the percentage retentions as they rose through the negative values at the lower levels of calcium, phosphorus, and nitrogen intakes and the flattening of the curves as the percentages of the retentions lessened with increases in intake. The numerical values of the average daily intakes after which the curves definitely flatten are 1.083 g. for calcium, 1.430 g. for phosphorus, and 11.34 g. for nitrogen.

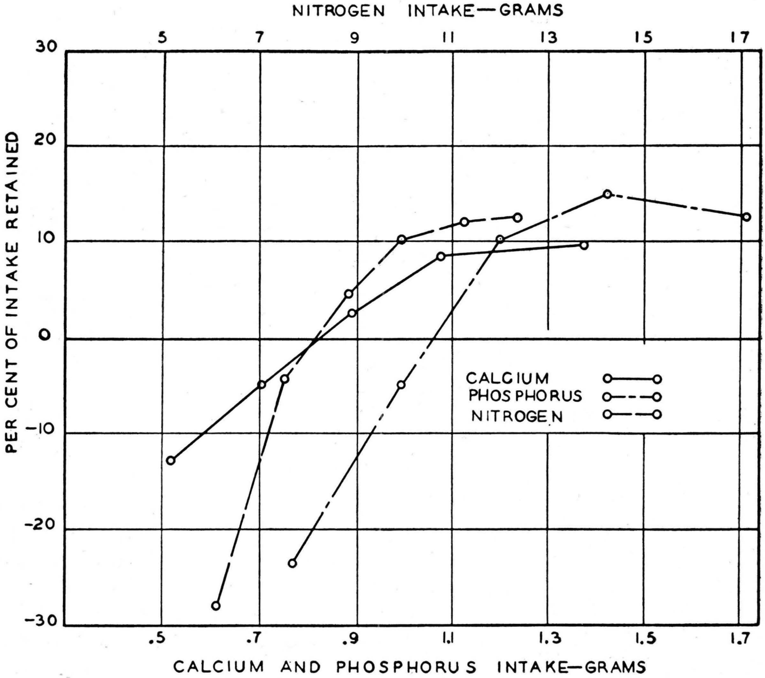

FIG. 6.—The relationship between the average daily intake of calcium, phosphorus, and nitrogen and the percentage of the intake that was retained for groups of subjects at different levels of intake.

Performance

Although the usual treatment of metabolism data is the preceding one, that is, from a standpoint of the relation of the size of the intake to the subsequent retention or loss, another approach is possible, namely from the standpoint of whether the subjects were in equilibrium or negative or positive balance. Grouping the subjects on this basis according to their performance regardless of their respective intakes brings out several relationships not otherwise evident.

In Table 16 are given the average daily intakes and retentions of each of the nutrients studied for the group of subjects in negative balance, those in equilibrium, and those in positive balance. All the subjects who had retentions or losses that were no greater than five per cent of respective intake were considered to be in equilibrium.

In the case of every nutrient the average of the intakes of the subjects in negative balance was lower than the average for the group in equilibrium and the group in positive balance. The group in positive balance always had the highest intake.

TABLE 16.—*Average daily intake and retention on the basis of performance.*

Performance	No. studies	Total average daily		Average daily per unit	
		Intake	Retention	Intake	Retention
		g.	*g.*	*mg.*	*mg.*
			CALCIUM		
Negative	27	0.696±.026	–0.145±.015	4.25 ±0.155	– 0.91 ±0.093
Equilibrium	31	0.875±.034	–0.002±.003	5.36 ±0.204	– 0.01 ±0.016
Positive	40	0.951±.023	0.135±.008	5.82 ±0.146	0.83 ±0.052
			PHOSPHORUS		
Negative	29	0.933±.021	–0.197±.016	16.11 ±0.417	– 3.53 ±0.337
Equilibrium	19	0.985±.019	0.007±.004	17.68 ±0.433	0.10 ±0.073
Positive	52	1.232±.019	0.173±.010	21.94 ±0.349	3.05 ±0.165
			IRON *(mg.)*		
Negative	13	8.76 ±.335	–1.14 ±.099	0.162±0.007	–0.021±0.002
Equilibrium	12	9.91 ±.267	–0.16 ±.045	0.176±0.005	–0.003±0.001
Positive	74	10.84 ±.189	2.06 ±.110	0.192±0.003	0.037±0.002
			NITROGEN		
Negative	12	7.18 ±.208	–1.36 ±.195	128.63 ±4.91	–24.13 ±3.84
Equilibrium	31	8.94 ±.164	0.05 ±.100	156.44 ±2.82	0.93 ±0.57
Positive	57	10.23 ±.104	1.29 ±.051	184.96 ±2.13	23.36 ±0.924

The average daily intakes of the groups that were in *negative* balance for each of the nutrients were less than the recommended allowances for these nutrients; that is, for the calcium the average intake of the subjects in negative balance was 0.696 g. as compared with the recommended allowance of 0.8 or 1.0 g. of calcium, depending on age; for phosphorus 0.933 as compared with 1.32 g.; for iron 8.76 mg. as compared with 12 or 15 mg.; and for nitrogen 7.18 as compared with 10 or 12 g., again depending on age. The groups in *equilibrium* had average daily intakes of 0.875 g. of calcium, 0.985 g. of phosphorus, 9.91 mg. of iron, and 8.94 g. of nitrogen. In the cases of the groups that were *storing* these nutrients the average intakes were 0.951 g. of calcium, 1.232 g. of phosphorus, 10.84 mg. of iron, and 10.23 g. of nitrogen.

Scoring of Individual Diets

Consideration of each nutrient separately has its value, but because deficiency states in human beings rarely involve only a single nutrient it is important to treat the results of this study in such a way as to assess the adequacy of each diet in all the nutrients that were studied. The method devised for this was one of scoring. The recent standards proposed by the Committee on Foods and Nutrition of the National Research Council were used as the basis for scoring the subjects' intakes. The amount equivalent to or within a range of ± 10 per cent of the recommended daily allowance for each nutrient was given a score of 3. For example, the recommended daily allowance for calcium is 1 g. for girls between 16 and 20 years, so any subject in this age range in the present study with a calcium intake between 0.9 and 1.1 g. was given a calcium intake score of 3; the recommended daily allowance for calcium is 0.8 g. for women over 20, so any subject over 20 who had a calcium intake between 0.72 and 0.88 g. was given a score of 3. The system for scoring was then further developed for intakes smaller than the recommended daily allowance and numerical values of 2 and 1 were given to these; intakes larger than the recommended standard were denoted by the figure 3+. The actual intervals and scores are given in Table 17.

TABLE 17.—*Score card for assessing over-all adequacy of each subject's diet.*

Score	Committee on Foods and Nutrition of the National Research Council			Sherman
	Calcium	Iron	Protein	Phosphorus
	g.	*mg.*	*g.*	*g.*
Girls 16—20 years				
1	Below 0.75	Below 11.3	Below 56	Below 0.97
2	0.75–0.89	11.3–13.4	56–66	0.97–1.16
3	0.9–1.1	13.5–16.5	67–82	1.17–1.43
3+	Above 1.1	Above 16.5	Above 82	Above 1.43
Women over 21 years				
1	Below 0.60	Below 9.0	Below 45	Below 0.97
2	0.60–0.71	9.0–10.7	45–53	0.97–1.16
3	0.72–0.88	10.8–13.2	54–66	1.17–1.43
3+	Above 0.88	Above 13.2	Above 66	Above 1.43

After a subject's intake was scored for each nutrient—calcium, phosphorus, iron, and nitrogen—the scores and plus signs were added to give a total intake score. Although the use of such a composite score in assessing over-all adequacy of a diet has decided limitations, it does furnish a simple means for quick recognition of the presence of outstanding deficiencies. A score of 12 means that the diet met the recommended allowances in each of the four nutrients, while a score of 12 followed by plus means that it exceeded the recommended allowances in as many nutrients as there were number of signs. Total intake scores of less than 12 mean inadequate amounts of one or more of the nutrients studied.

There were 91 subjects who had a total intake score below 12 and only 9 who had total scores of 12 or above. This means that 91 subjects were without question below the standard allowance in one or more of the four nutrients. One extreme in the quality of the diets of the 100 studies is represented by the 9 subjects who had total scores of 12 because these diets were adequate in the four nutrients studied and the other extreme by the 21 subjects who had total scores of 4 and 5 because these diets had inadequate amounts of each of the four nutrients. The averages of the daily intake and retention of calcium, phosphorus, iron, and nitrogen for these two groups are as follows:

	Nine subjects with scores of 12		Twenty-one subjects with scores of 4 and 5	
	Intake	*Retention*	*Intake*	*Retention*
Calcium (*g.*)	1.097	0.061	0.575	–0.071
Phosphorus (*g.*)	1.425	0.202	0.814	–0.034
Iron (*mg.*)	13.74	2.27	9.12	0.85
Nitrogen (*g.*)	11.14	1.23	7.61	0.29
Protein (*g.*)	69.63	7.69	47.59	1.81

When the over-all adequacy of individual diets is being considered, the metabolic performance of the girls regardless of the level of their intakes of the dietary essentials is also important. Of the 100 subjects 19 were storing all four nutrients at the time they were studied. The averages of the daily intakes of calcium, phosphorus, iron, and nitrogen for the 19 were as follows:

	Intake	*Retention*
Calcium (*g.*)	1.054	0.155
Phosphorus (*g.*)	1.346	0.188
Iron (*mg.*)	11.63	2.56
Nitrogen (*g.*)	10.39	1.58
Protein (*g.*)	64.94	9.87

It may be readily seen that these amounts are generous and well above the averages for the 100 studies. Two girls (Subject 18h, 26h, 62h and Subject 37o, 69o, 101o) were each in this group three of the four times they were studied. Frequently two or three girls doing light housekeeping together would appear in this group.

There were only two subjects that were in negative balance in the four nutrients studied; there were three others that were in negative balance or equilibrium in every nutrient, and 21 that were in positive balance in only one nutrient.

DISCUSSION

Metabolism of any nutrient is influenced by the nutritional status of the subject or the extent to which her nutritional needs have been supplied all through the growing period. For this reason recommendations based on the results of metabolism studies have to be made carefully and with qualifications. A recommendation for the later years of maturation made on the assumption that a young woman has always been supplied with optimum amounts of the dietary essentials could suggest an intake quite inadequate to meet the demands for the maturation of a malnourished body.

There is also the problem in this age group of knowing whether recommendations for standard allowance should allow for storage, and if so, for how much storage. There is no evidence that the storage in the normal body of minerals and vitamins from food can proceed to a point at which such storage becomes harmful and there is much more evidence that a body well stocked with these nutrients functions at a higher level of efficiency and satisfaction than one less well supplied.

After a certain point, however, the level of intake required to promote additional storage may be very high in comparison with the retention accomplished. This, together with the fact that the body seems to use liberal supplies less economically than it does limited supplies, makes the maintenance of the body at a luxus level expensive and thus impractical for many.

To determine the level of intake of a nutrient which will be above the borderline, that is in the safety zone, and which will give the maximum return in general well-being for the amount ingested, is the challenge made by metabolism results such as these just presented.

Reference to Figure 6, which shows the percentage of each nutrient retained at different levels of intake, offers help in determining what recommended allowances can meet this challenge. On this graph is plotted for each nutrient the percentage retention at each level of intake. The levels of intake are taken from Table 8, which gives the average metabolism data of the different groups of subjects arranged according to the level of intake. It will be observed that a line has been drawn denoting equilibrium. Any points below this line indicate that the groups were in negative balance and to what extent the intakes failed to cover the excretions; points above this equilibrium line indicate the percentage of the respective intakes that were stored. When a line is drawn to join these points it begins with a steep rise and then definitely flattens at the higher intakes. From this graph may be read the point on the intake scale at which the retention line crosses the equilibrium line, or the intake at which there would be neither negative balance nor storage. Also from the graph may be read the level of intake at the top of the steep line just before it flattens, or the intake above which there are only slight increases in retention with additional intakes. These two figures could well correspond to the commonly termed "minimal requirement" and "optimal allowance" and for the different nutrients are as follows:

	"Minimal requirement"	"Optimal allowance"
Calcium (*g.*)	0.83	1.08
Phosphorus (*g.*)	1.06	1.43
Nitrogen (*g.*)	8.15	11.34
Protein (*g.*)	50.94	70.87

In this case the "optimal allowances" are not 50 per cent higher than the "minimal requirements" as is true of earlier standards but only 30 per cent higher for calcium, 35 per cent for phosphorus, and 39 per cent for nitrogen and protein. Some of this lower percentage difference between the two values is a result of the "minimal requirements" evolved from these data being higher than those of Sherman's standards (0.45 g. calcium, 0.88 g. phosphorus, 45.0 g. protein); the "optimal allowances" are slightly higher too.

The "minimal requirement" for calcium as it is read from the graph, 0.83 g. per day, is almost identical with the average daily intake of the 100 subjects (0.857 g.) and the average retention on this intake was 0.011 g., which was equivalent to equilibrium. Also the average of the daily intakes of the 31 subjects who were in calcium equilibrium was 0.875 g. The close agreement of these figures strengthens the evidence that a total daily intake of 0.83 to 0.88 g. of calcium, or 5.2 mg. per centimeter, is necessary for maintenance in young women similar to the group studied here.

An intake of one gram, however, appears more desirable, for there is significant storage of the additional intake regardless of the age or nutritional background of the subject.

In view of these findings the 0.8 g. of calcium daily proposed by the Committee on Foods and Nutrition of the National Research Council for women over 21 years certainly could not be considered too high, and the recommendation of 1.0 g., which is made for girls from 16 through 20 years, could well be continued through maturation. Since even with large intakes of calcium negative balances are likely to occur with the onset of lactation, the reserve calcium stores that result from a daily intake of 1.0 g. probably justify recommending this amount for all women between their reproductive periods.

This one gram of calcium a day, though higher than customary standards for this age, is not unattainable from daily foods and has the added advantage that when milk products are used as a source of calcium they also make valuable contributions to the intake of other dietary essentials.

The "minimal requirement" for phosphorus is 1.06, as compared with 1.43 g. for the "optimal allowance." The Committee on Foods and Nutrition of the National Research Council made no recommendations for this nutrient but these values are similar to Sherman's 0.88 g. and 1.32 g. for the adult standards. It is unfortunate that metabolism figures for phosphorus receive so little attention. Metabolically it is closely associated with both calcium and nitrogen and it has the advantage that a large proportion of the amount excreted is in the urine and therefore is less subject to errors in collection or "marking" during metabolism studies. Also the method for its quantitative determination is relatively simple. If it were possible, therefore, to interpret thoroughly the findings of phosphorus metabolism studies, much more might be known of calcium and nitrogen metabolism.

When the nitrogen values are expressed in terms of protein the daily "minimal requirement" is 50.94 g. and the "optimal allowance" 70.78 g. These correspond closely to Sherman's figures for a 70-kilogram man although the practice has been to reduce his figures for a 56-kilogram woman. The Committee on Foods and Nutrition of the National Research Council recommends 75 g. of protein for girls 16 through 20 years and then drops the amount to 60 g. for 21 years and over. Low protein intakes among women are rather prevalent and there is a good deal of evidence that a generous protein intake contributes definitely to the maintenance of normal hemoglobin values and to general well-being. A daily intake of 70 g. as indicated here would require considerable education and adjustment in food habits in order to have this amount attainable from common foods at reasonable cost.

The results of the studies of the iron metabolism of these subjects have been published separately in a journal article *(16)* and the discussion is quoted here.

"If one accepts the premise that the intestinal tract does not re-excrete iron, the significance of observed negative balances in iron metabolism studies is problematic. Their occurrence may be attributable to such factors as: (1) too short a period of study, (2) an atypical state of the subject, (3) difficulty in separating the carmine-marked and unmarked portions of the feces, (4) an abnormal permeability of the individual's intestinal tract to the re-excretion of iron from the body. The same factor together with adsorption of iron by the intestinal mucosa could also operate to produce fictitious storages of iron. While these factors may apply to occasional individual cases it may be safely assumed that 99 studies would give a typical cross-section of the iron metabolism of a group of normal young women and show whether they were storing enough to replace menstrual losses.

"The practical significance of these results of the entire study is the finding that the customary intake of iron of young women on self-chosen diets permits a storage of more than enough to replace the iron lost in the menses and that two-thirds of this amount would be sufficient if the diet were generous in other nutrients.

"This figure 10.44 mg. as the average daily intake of the group and as promoting a daily storage of 1.37 mg. is valuable in showing group performance but it overlooks the individual subjects who were in negative balance. In these cases of apparent negative balance regardless of the level of intake the correction would seem to be in the general improvement of the diet with larger quantities of protective foods rather than in an increased iron intake.

"This influence of the quality of the diet upon the absorption of iron, especially at low levels of intake, has been observed in other studies in this laboratory. When a group of college women with simple hypochromic anemia was given daily supplements of vitamin B complex or additional protein from dry milk, cheese, and peanuts the hemoglobin content of their blood increased even though no medicinal iron was given *(15)*. Also, when four young women had a generous diet except that the daily iron intakes were between 3.5 and 4.5 mg. for several months they remained in excellent health and there was no marked decrease in hemoglobin *(14)*. When their iron intake was increased to 6.55 mg. their average daily storage was 2.44 mg.

"The effect of 99 studies reported here upon the dietary recommendations for iron is less than might be expected. While the results show that the chances of storing iron are greater at higher levels of intake, they also show that ample storage occurred at surprisingly low intakes when the diet was rich in other nutrients. A diet could be high in iron and poor in protective foods but if it were rich in protective foods it could hardly be deficient in iron—both because the protective foods are good sources of iron and because the amount of iron required appears to be small if the supply of other nutrients is liberal. It follows then that a well-balanced optimum diet for the treatment of simple hypochromic anemia in young women probably holds more promise for a permanent general improvement than iron medication."

When the over-all adequacy of the diet of each subject was assessed on the basis of daily allowances suggested by the Committee on Foods and Nutrition of the National Research Council, 82 subjects were deficient in one or more nutrients.

However, 19 of the 100 subjects were storing all four nutrients (calcium, phosphorus, iron, and nitrogen) and the average of their daily intakes corresponds almost exactly to the "optimal allowance" for each nutrient as developed from the results of the entire study.

The "optimal allowances" developed from this study and the recommendation that they be accepted for general use instead of the "minimal requirements" may be criticized by those who feel that standards for an adequate diet are constantly being raised. However, there is no doubt that the metabolic performance of this group of young women was better on the higher levels of intake. Recommendations have frequently been based on studies of subjects selected for their nutritional background, or on subjects whose stores have first been filled and who were then fed controlled diets. Considering the prevalence of malnutrition in the United States, however, recommendations based on the results from such studies as this, of a large number of young women on their customary diets, may better meet present-day needs. The results of this study, made on freely chosen diets, show that the recommendations of the Committee on Foods and Nutrition of the National Research Council for young women are not too high and that the calcium allowance recommended by the Committee for girls from 16 to 20 could well be extended to apply to women over 21 years.

SUMMARY AND CONCLUSIONS

The study reported was undertaken to add appreciably to the data available on the metabolism of calcium, phosphorus, iron, and nitrogen of young women between the ages of 16 and 27 years on their customary self-chosen diets and thus to evaluate the suitability of present adult dietary standards for the intermediate period of late adolescence and early adulthood. Between the fall of 1937 and the spring of 1940, one hundred metabolism studies which included the analysis of the food intake and the fecal and urinary excretion for periods of one week were made on 70 healthy college women. Fifty-three individuals were studied once, 7 twice, 7 three times, and 3 four times.

Because one of the greatest values of the results lies in the number of subjects studied, emphasis is placed upon average figures and figures for groups of subjects sorted according to the size of intake of the nutrients studied.

As was to be expected, in the case of every nutrient the least retention or the largest negative balance occurred on the lowest intake, and as the intakes rose the occurrence of negative balances decreased and finally disappeared, and the size of retentions increased. When the figures were sorted into groups according to performance (those subjects in positive balance, those in negative, and those in equilibrium) the same trend of storing on higher intakes of the nutrient was demonstrated.

The figures for the average daily intakes and retentions of the four nutrients were as follows:

	Intake		Retention	
Nutrient	*Range*	*Average*	*Range*	*Average*
Calcium (*g.*)	0.421 to 1.679	0.857	– 0.463 to 0.377	0.013
Phosphorus (*g.*)	0.629 to 1.806	1.088	– 0.458 to 0.572	0.033
Iron (*mg.*)	5.94 to 16.71	10.44	– 2.12 to 6.50	1.37
Nitrogen (*g.*)	5.55 to 12.77	9.46	– 3.50 to 2.49	0.58
Protein (*g.*)	34.69 to 79.81	59.13	–21.87 to 15.56	3.63

Seventeen subjects studied two to four times each offered additional evidence that intra-individual variation is less than inter-individual variation.

That body size had an effect on metabolism or requirement could not be demonstrated, probably because its influence was far overshadowed by the more dominant factor of the nutritional background of the subjects.

On the basis of the percentage of each nutrient retained at different levels of intake a recommendation for "minimal requirement" and "optimal allowance" seems justified. These figures for the different nutrients are as follows:

	"Minimal requirement"	"Optimal allowance"
Calcium (*g.*)	0.83	1.08
Phosphorus (*g.*)	1.06	1.43
Nitrogen (*g.*)	8.15	11.34
Protein (*g.*)	50.94	70.87

The results of the iron metabolism studies of these young women bear out the earlier conclusion from this laboratory that if the diet is generous in essential nutrients, other than iron, which have been shown to promote efficient iron absorption and utilization, there will be a sufficient amount of iron to meet daily needs and to replace that lost during menstruation even at as low a level of intake as 7.21 mg. daily.

Results from such studies as this of a large number of young women on their customary freely chosen diets have given a justifiable basis upon which dietary recommendations may be made for women similar to those studied here.

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APPENDIX

TABLE I.—*Individual data on the average daily calcium, phosphorus, iron, and nitrogen metabolism for 100 subjects for one week.*

Subject	Age	Wt.	Ht.	CALCIUM					PHOSPHORUS					IRON			NITROGEN				
				Intake	Urine	Feces	Total	Retention	Intake	Urine	Feces	Total	Retention	Intake	Output	Retention	Intake	Urine	Feces	Total	Retention
	yr.-mo.	*kg.*	*cm.*	*g.*	*g.*	*g.*	*g.*	*g.*	*g.*	*g.*	*g.*	*g.*	*g.*	*mg.*	*mg.*	*g.*	*g.*	*g.*	*g.*	*g.*	*g.*
SCHOOL YEAR 1937-38																					
1a	19— 3	56.0	161.3	0.539	0.128	0.394	0.522	0.017	0.732	0.433	0.337	0.770	–0.038	9.77	9.20	0.57	6.92	6.00	1.51	7.51	–0.59
2	21— 3	47.5	148.6	0.499	0.098	0.682	0.780	–0.281	0.713	0.411	0.211	0.622	0.091	9.49	8.76	0.73	6.76	5.36	1.09	6.45	0.31
3b	24—11	62.8	166.3	0.908	0.096	0.660	0.756	0.152	1.019	0.493	0.561	1.054	–0.035	9.56	9.00	0.56	8.77	7.26	1.32	8.58	0.19
4c	21— 2	58.3	162.0	1.021	0.154	0.617	0.771	0.250	1.162	0.487	0.478	0.965	0.197	10.20	10.15	0.05	10.44	6.97	1.68	8.65	1.79
5d	24— 2	60.9	163.8	0.948	0.200	0.757	0.957	–0.009	1.123	0.586	0.487	1.073	0.050	9.56	9.00	0.56	9.73	7.70	0.98	8.68	1.05
6	20— 9	77.3	167.9	1.007	0.135	0.727	0.862	0.145	1.148	0.549	0.567	1.116	0.032	8.53	8.14	0.39	9.75	8.76	1.03	9.79	–0.04
7e	22— 5	54.4	165.1	0.891	0.104	0.826	0.930	–0.039	1.108	0.623	0.419	1.042	0.066	10.46	10.85	–0.39	9.90	8.34	1.33	9.67	0.23
8f	18— 0	53.2	162.6	1.141	0.072	0.860	0.932	0.209	1.268	0.521	0.576	1.097	0.171	8.37	7.84	0.53	9.45	7.87	1.18	9.05	0.40
9	20— 7	61.9	160.0	0.591	0.135	0.359	0.494	0.097	0.821	0.424	0.431	0.855	–0.034	8.40	9.97	–1.57	7.45	5.86	1.19	7.05	0.40
10	18— 0	49.4	156.9	0.741	0.381	0.463	0.844	–0.103	0.934	0.393	0.382	0.775	0.159	8.97	9.46	–0.49	8.50	6.61	1.09	7.70	0.80
11g	18— 4	54.8	165.1	0.625	0.277	0.526	0.803	–0.178	0.876	0.524	0.381	0.905	–0.029	9.09	8.63	0.46	8.39	6.79	1.25	8.04	0.35
12h	18— 9	52.6	168.5	1.015	0.143	0.824	0.967	0.048	1.247	0.532	0.532	1.064	0.183	10.69	10.20	0.49	11.74	8.98	1.17	10.15	1.59
13	21— 7	53.5	163.5	0.752	0.073	0.763	0.836	–0.084	1.134	0.528	0.601	1.129	0.005	10.00	9.46	0.54	9.89	8.39	1.13	9.52	0.37
14d	24— 6	60.9	163.8	0.772	0.175	0.544	0.719	0.053	1.092	0.548	0.503	1.051	0.041	12.38	13.09	–0.71	8.36	7.45	1.02	8.47	–0.11
15	20— 7	56.0	158.2	0.681	0.157	0.429	0.586	0.095	1.111	0.704	0.346	1.050	0.061	15.41	12.44	2.97	7.60	8.94	0.74	9.68	–2.08
16	19— 8	59.5	157.5	0.441	0.157	0.274	0.431	0.010	1.134	0.523	0.357	0.880	0.254	13.14	10.15	2.99	7.02	7.54	0.91	8.45	–1.43
17i	19— 7	65.5	169.0	0.527	0.058	0.544	0.602	–0.075	0.738	0.728	0.458	1.186	–0.448	7.89	9.54	–1.65	5.89	8.35	1.04	9.39	–3.50
18h	19— 1	53.2	168.5	1.027	0.118	0.817	0.935	0.092	1.449	0.678	0.539	1.217	0.232	15.70	12.65	3.05	11.50	9.55	0.94	10.49	1.01
19e	22— 9	53.6	165.0	0.846	0.089	0.715	0.804	0.042	0.982	0.581	0.327	0.908	0.074	10.14	8.23	1.91	8.01	7.08	1.03	8.11	–0.10
20a	19— 9	61.4	161.3	0.934	0.149	0.519	0.668	0.266	1.168	0.662	0.401	1.063	0.105	12.21	9.70	2.51	9.30	7.55	1.40	8.95	0.35
21	24— 0	60.5	162.6	1.047	0.112	0.961	1.073	–0.026	1.058	0.513	0.731	1.244	–0.186	10.97	11.41	–0.44	9.24	8.84	0.87	9.71	–0.47
22	22— 4	53.7	165.0	0.761	0.109	0.580	0.689	0.072	0.783	0.471	0.378	0.849	–0.066	10.76	11.29	–0.53	7.22	6.79	0.84	7.63	–0.41
23g	18— 9	52.3	165.1	0.643	0.120	0.484	0.604	0.039	0.954	0.547	0.319	0.866	0.088	10.67	9.00	1.67	8.45	7.31	0.81	8.12	0.33
24	19— 3	58.3	163.0	0.546	0.138	0.442	0.580	–0.034	0.935	0.573	0.346	0.919	0.016	10.11	7.62	2.49	8.03	6.92	1.14	8.06	–0.03
SCHOOL YEAR 1938-39																					
26h	19— 8	52.2	168.5	1.160	0.168	0.872	1.040	0.120	1.400	0.681	0.537	1.218	0.182	9.71	7.77	1.94	10.50	7.36	1.37	8.73	1.77
27j	19— 0	48.5	162.6	0.940	0.248	0.553	0.801	0.139	1.343	0.629	0.491	1.120	0.223	10.99	11.31	–0.32	9.76	6.93	1.05	7.98	1.78
28k	20—10	52.8	163.8	0.960	0.192	0.657	0.849	0.111	1.371	0.648	0.537	1.185	0.186	12.73	12.00	0.73	9.67	7.03	1.29	8.32	1.35
29b	25—10	57.6	166.3	0.840	0.131	0.723	0.854	–0.014	1.144	0.620	0.473	1.093	0.051	8.62	7.49	1.13	9.01	8.28	1.11	9.39	–0.38
30a	20— 3	59.4	161.3	0.530	0.158	0.410	0.568	–0.038	1.053	0.555	0.311	0.866	0.187	7.97	8.40	–0.43	6.67	6.56	0.92	7.48	–0.81
31i	20— 3	59.9	169.0	0.440	0.060	0.404	0.464	–0.024	0.914	0.699	0.282	0.981	–0.067	6.29	7.31	–1.02	6.95	6.10	0.76	6.86	0.09
32c	22— 2	55.3	162.0	0.823	0.212	0.466	0.678	0.145	1.274	0.596	0.389	0.985	0.289	12.92	10.99	1.93	11.50	8.30	1.49	9.79	1.71
33l	20— 7	67.6	162.6	0.674	0.090	0.499	0.589	0.085	1.182	0.582	0.366	0.948	0.234	11.31	8.29	3.02	9.72	6.96	1.34	8.30	1.42
34m	22— 5	59.9	158.8	0.618	0.198	0.449	0.647	–0.029	1.163	0.679	0.398	1.077	0.086	10.89	9.66	1.23	10.10	8.55	0.94	9.49	0.61
35n	18— 0	64.4	170.4	0.773	0.125	0.552	0.677	0.096	1.174	0.655	0.404	1.059	0.115	13.07	11.77	1.30	10.70	8.44	1.57	10.01	0.69
36	18— 3	55.8	162.6	1.038	0.131	0.669	0.800	0.238	1.248	0.630	0.420	1.050	0.198	11.45	9.54	1.91	10.10	6.35	1.35	7.70	2.40
37o	16— 8	50.8	159.4	1.213	0.156	0.714	0.870	0.343	1.391	0.863	0.342	1.205	0.186	15.87	10.17	5.70	10.90	7.70	1.33	9.03	1.87
38p	17— 4	44.9	162.6	0.542	0.176	0.432	0.608	–0.066	0.991	0.602	0.303	0.905	0.086	13.16	11.43	1.73	8.94	7.05	1.04	8.09	0.85
39q	18—10	48.5	152.4	0.631	0.126	0.513	0.639	–0.008	0.923	0.475	0.222	0.697	0.226	9.65	11.06	–1.41	7.96	7.22	1.03	8.25	–0.29
40f	19— 2	57.1	162.6	1.272	0.181	0.988	1.169	0.103	1.370	0.692	0.571	1.263	0.107	9.92	5.71	4.21	11.21	9.52	1.14	10.66	0.55
41	18—11	53.5	162.6	1.114	0.208	0.919	1.127	–0.013	1.268	0.768	0.465	1.233	0.035	11.22	7.77	3.45	10.75	9.19	1.17	10.36	0.39
42	17— 4	56.8	157.5	0.912	0.134	0.826	0.960	–0.048	1.140	0.587	0.495	1.082	0.058	9.63	9.54	0.09	10.04	7.75	1.15	8.90	1.14
43	17— 5	58.5	161.3	1.008	0.201	0.664	0.865	0.143	1.156	0.655	0.408	1.063	0.093	8.65	7.66	0.99	10.24	8.23	1.19	9.42	0.82
44	19— 3	64.4	162.6	1.28[illegible]	0.202	0.956	1.[illegible]58	0.125	[illegible].660	0.948	0.571	1.51[illegible]	0.141	10.33	[illegible].97	1.36	11.48	9.03	1.49	10.52	0.96
45	24— 2	60.8	16[illegible].3	1.338	0.133	1.067	1.200	0.138	1.544	0.804	0.587	1.391	0.[illegible]53	16.14	11.99	4.12	10.70	8.[illegible]	1.46	9.46	1.24

46	24— 6	67.1	151.8	1.507	0.144	1.137	1.281	0.226	1.690	0.775	0.669	1.444	0.246	13.70	12.47	1.23	11.35	7.45	1.41	8.86	2.49
47	25— 2	67.6	163.2	0.77[illegible]	0.117	0.791	0.908	–0.136	1.244	0.664	0.480	1.144	0.100	12.73	12.91	–0.18	8.72	6.76	1.72	8.48	0.24
48	21—11	56.7	168.9	0.748	0.402	0.617	1.019	–0.271	1.170	0.609	0.426	1.035	0.135	13.64	11.25	2.39	8.24	6.16	1.15	7.31	0.93
49	21— 0	54.2	162.6	1.072	0.174	0.886	1.060	0.012	1.463	0.704	0.636	1.340	0.123	12.14	10.47	1.67	12.77	9.39	1.63	11.02	1.75
50	20— 7	44.5	158.8	0.589	0.202	0.351	0.553	0.036	0.771	0.513	0.259	0.772	–0.001	7.26	6.74	0.52	7.24	6.17	0.89	7.06	0.18
51	19— 9	67.6	174.0	0.941	0.167	0.702	0.869	0.072	1.277	0.782	0.413	1.195	0.082	11.43	10.17	1.26	12.37	9.28	1.18	10.46	1.91
52	19—11	56.3	166.4	0.921	0.132	0.857	0.989	–0.068	1.260	0.701	0.480	1.181	0.079	8.45	8.70	–0.25	11.84	10.83	1.22	12.05	–0.21
53	19—10	52.6	154.3	0.836	0.072	0.761	0.833	0.003	1.178	0.532	0.512	1.044	0.134	11.81	10.73	1.08	9.54	7.05	1.42	8.47	1.07
54a	20— 8	58.3	161.3	0.668	0.157	0.503	0.660	0.008	0.887	0.473	0.407	0.880	0.007	11.65	8.11	3.54	7.94	7.00	0.98	7.98	–0.04
55	23— 8	59.9	163.8	0.692	0.121	0.602	0.723	–0.031	0.926	0.581	0.400	0.981	–0.055	15.87	12.23	3.64	9.82	7.97	1.02	8.99	0.83
56	23—10	58.5	167.6	0.682	0.112	0.547	0.659	0.023	0.789	0.602	0.320	0.922	–0.133	13.66	8.86	4.80	8.21	6.47	0.96	7.43	0.78
57j	19— 5	49.0	162.6	0.791	0.173	0.591	0.764	0.027	1.046	0.534	0.492	1.026	0.020	11.14	12.63	–1.49	9.24	7.35	1.14	8.49	0.75
58k	21— 3	52.6	163.8	0.737	0.168	0.524	0.692	0.045	0.986	0.619	0.431	1.050	–0.064	11.43	10.80	0.63	8.47	6.80	1.24	8.04	0.43
59p	17— 8	46.3	162.6	0.552	0.116	0.455	0.571	–0.019	0.780	0.538	0.304	0.842	–0.062	9.91	7.66	2.25	7.32	6.69	0.85	7.54	–0.22
60q	19— 2	47.2	153.7	0.686	0.113	0.642	0.755	–0.069	0.943	0.561	0.480	1.041	–0.098	6.29	8.06	–1.77	6.10	8.28	0.91	9.19	–3.09
61	18— 0	44.5	154.3	0.858	0.151	0.713	0.864	–0.006	1.086	0.603	0.478	1.081	0.005	...	...	...	8.17	6.14	1.03	7.17	1.00
62h	20— 1	53.1	168.8	1.157	0.157	0.863	1.020	0.137	1.330	0.579	0.561	1.140	0.190	11.08	6.97	4.11	10.65	8.05	0.93	8.98	1.67
63c	22— 6	54.9	162.0	0.732	0.193	0.465	0.658	0.074	0.951	0.571	0.398	0.969	–0.018	8.03	8.29	–0.26	8.97	6.95	1.29	8.24	0.73
64l	20—11	66.2	162.6	0.674	0.092	0.565	0.657	0.017	0.840	0.562	0.410	0.972	–0.132	8.55	5.43	3.12	7.67	6.85	0.97	7.82	–0.15
65m	22— 9	57.6	158.8	0.683	0.151	0.486	0.637	0.046	0.771	0.617	0.440	1.057	–0.286	10.10	6.97	3.13	8.18	7.49	1.55	9.04	–0.86
66n	18— 4	65.3	170.2	0.838	0.121	0.711	0.832	0.006	1.024	0.648	0.509	1.157	–0.133	11.43	8.06	3.37	9.98	8.25	1.23	9.48	0.50
67	21— 5	49.9	160.0	0.869	0.243	0.649	0.892	–0.023	1.071	0.539	0.525	1.064	0.007	9.84	6.63	3.21	9.27	7.01	1.17	8.18	1.09
68i	20— 8	62.1	169.0	0.421	0.047	0.472	0.519	–0.098	0.663	0.532	0.387	0.919	–0.256	10.03	8.34	1.69	5.55	6.27	0.95	7.22	–1.67
69o	17— 1	51.5	159.4	1.083	0.207	0.722	0.929	0.154	1.097	0.644	0.369	1.013	0.084	7.47	4.00	3.47	9.28	6.68	0.89	7.57	1.71
SCHOOL YEAR 1939-40																					
70g	20— 4	55.3	164.5	1.068	0.176	0.888	1.064	0.004	1.038	0.640	0.609	1.249	–0.211	10.06	10.86	–0.80	10.59	7.42	1.53	8.95	1.64
71f	19—11	54.9	163.8	1.037	0.147	0.891	1.038	–0.001	1.221	0.559	0.571	1.130	0.091	9.89	6.40	3.49	9.53	6.89	1.45	8.34	1.19
72	22— 5	51.3	165.1	0.977	0.230	0.778	1.008	–0.031	1.055	0.687	0.786	1.473	–0.418	11.06	8.91	2.15	10.82	7.79	1.25	9.04	1.78
73m	23— 5	57.6	158.8	0.997	0.162	0.724	0.886	0.111	0.775	0.631	0.514	1.145	–0.370	9.91	9.97	–0.06	10.77	7.54	1.84	9.38	1.39
74o	17— 8	51.0	159.4	1.169	0.220	1.067	1.287	–0.118	0.844	0.741	0.453	1.194	–0.350	7.41	5.66	1.75	11.28	8.13	0.92	9.05	2.23
75	17—11	50.1	152.4	0.748	0.245	1.151	1.396	–0.648	0.689	0.621	0.549	1.170	–0.481	7.37	9.49	–2.12	10.80	6.66	1.91	8.57	2.23
76	20— 8	62.6	163.8	1.532	0.219	1.323	1.542	–0.010	1.112	0.756	0.636	1.392	–0.280	9.60	7.79	1.81	10.08	9.12	1.42	10.54	–0.46
77	20— 6	48.3	160.0	1.096	0.219	1.037	1.256	–0.160	0.813	0.695	0.312	1.007	–0.194	6.68	5.86	0.82	9.92	8.23	0.99	9.22	0.70
78q	19—10	48.5	153.7	0.469	0.119	0.813	0.932	–0.463	0.783	0.449	0.792	1.241	–0.458	9.56	10.11	–0.55	9.82	7.30	1.55	8.85	0.97
79	18— 7	62.1	154.9	0.581	0.118	0.508	0.626	–0.045	1.025	0.532	0.442	0.974	0.051	10.17	9.39	0.78	10.97	8.10	1.13	9.23	1.74
80	27— 0	51.5	165.1	0.667	0.213	0.526	0.739	–0.072	1.074	0.700	0.427	1.127	–0.053	12.63	9.01	3.62	10.97	8.96	1.31	10.27	0.70
81	20—10	50.8	165.1	1.131	0.118	1.027	1.145	–0.014	1.231	0.498	0.803	1.301	–0.070	8.97	8.75	0.22	8.72	8.29	0.88	9.17	–0.45
82e	24— 8	51.7	168.3	1.025	0.087	0.789	0.876	0.149	1.067	0.527	0.377	0.904	0.163	8.23	6.74	1.49	7.83	7.01	1.05	8.06	–0.23
83	20— 1	48.5	156.2	0.571	0.145	0.414	0.559	0.012	0.849	0.497	0.351	0.848	0.001	8.89	7.66	1.23	9.60	7.60	1.22	8.82	0.78
84	17— 9	49.0	152.4	1.046	0.126	0.285	0.411	0.635	0.629	0.471	0.267	0.738	–0.109	6.74	7.57	–0.83	7.09	7.03	1.00	8.03	–0.94
85	23— 0	64.0	172.7	0.957	0.109	1.021	1.130	–0.173	0.724	0.606	0.442	1.048	–0.324	11.43	9.94	1.49	9.40	7.97	1.52	9.49	–0.09
86	21— 6	66.9	169.6	0.804	0.122	0.748	0.870	–0.066	1.086	0.679	0.404	1.083	0.003	9.60	8.91	0.69	9.60	8.26	1.20	9.46	0.14
87	21— 0	54.4	167.0	1.172	0.202	0.922	1.124	0.048	1.501	0.685	0.533	1.218	0.283	11.43	9.60	1.83	12.20	9.94	1.26	11.20	1.00
88	21— 4	56.3	166.4	0.716	0.087	0.967	1.054	–0.338	1.019	0.607	0.507	1.114	–0.095	9.77	7.83	1.94	11.54	9.73	1.14	10.87	0.67
89	22— 6	55.8	162.6	1.125	0.172	0.576	0.748	0.377	1.379	0.807	0.254	1.061	0.318	7.89	3.94	3.95	10.06	7.51	0.58	8.09	1.97
90	20— 5	55.8	165.1	1.679	0.322	1.343	1.665	0.014	1.806	1.009	0.551	1.560	0.246	7.66	5.71	1.95	11.92	8.57	1.08	9.65	2.27
91	22— 6	58.1	162.6	0.880	0.175	0.575	0.750	0.130	1.181	0.269	0.340	0.609	0.572	7.77	7.67	0.10	9.69	6.79	0.69	7.48	2.21
92	20— 8	57.6	167.6	0.639	0.553	0.435	0.988	–0.349	0.869	0.533	0.303	0.836	0.033	6.80	6.21	0.59	8.63	7.78	0.99	8.77	–0.14
93	20—10	61.7	174.0	0.837	0.140	0.503	0.643	0.194	1.189	0.706	0.103	0.809	0.380	15.30	8.80	6.50	11.37	10.04	1.37	11.41	–0.04
94	21— 7	57.1	160.0	0.519	0.110	0.439	0.549	–0.030	0.899	0.463	0.331	0.794	0.105	8.61	7.71	0.90	8.63	7.27	0.90	8.17	0.46
95	23— 2	58.9	169.6	0.551	0.127	0.630	0.757	–0.206	1.051	0.625	0.495	1.120	–0.069	11.14	10.00	1.14	11.32	9.23	1.20	10.43	0.89
96	19—10	53.1	166.4	1.117	0.174	0.820	0.994	0.123	1.433	0.766	0.411	1.177	0.256	8.73	6.76	1.97	11.32	9.00	0.95	9.95	1.37
97	19— 0	65.3	154.9	0.724	0.124	0.521	0.645	0.079	1.200	0.566	0.474	1.040	0.160	16.71	10.82	5.89	11.72	8.53	0.79	9.32	2.40
98	18— 5	49.9	166.4	0.499	0.166	0.351	0.517	–0.018	0.808	0.498	0.339	0.837	–0.029	11.43	10.23	1.20	8.00	7.07	0.81	7.88	0.12
99	20— 8	62.6	172.7	0.846	0.160	0.702	0.862	–0.016	1.249	0.693	0.125	0.818	0.431	12.57	11.09	1.48	10.14	8.40	0.90	9.30	0.84
100	22— 1	64.9	179.1	0.951	0.278	0.995	1.273	–0.322	1.272	0.852	0.625	1.477	–0.205	13.03	12.00	1.03	10.60	9.24	1.58	10.82	–0.22
101o	18— 1	51.3	159.4	1.084	0.168	0.778	0.946	0.138	1.311	0.649	0.442	1.091	0.220	5.94	5.17	0.77	9.32	7.15	0.90	8.05	1.27

APPENDIX

TABLE II.—*Individual data on the average daily intake and retention of calcium per centimeter and on phosphorus, iron, and nitrogen per kilogram for 100 subjects for one week.*

Subject No. [1]	Calcium		Phosphorus		Iron		Nitrogen	
	Intake	Retention	Intake	Retention	Intake	Retention	Intake	Retention
	mg./cm.	*mg./cm.*	*mg./kg.*	*mg./kg.*	*mg./kg.*	*mg./kg.*	*mg./kg.*	*mg./kg.*
1a	3.34	0.11	13.07	−0.68	0.175	0.010	123.57	−10.53
2	3.36	−1.89	15.01	1.91	0.200	0.015	142.31	6.53
3b	5.46	0.91	16.23	−0.56	0.152	0.009	139.65	3.03
4c	6.30	1.54	19.93	3.38	0.175	0.001	179.07	30.70
5d	5.79	−0.05	18.44	0.82	0.157	0.009	159.77	17.24
6	6.00	0.86	14.85	0.41	0.110	0.005	126.13	− 0.52
7e	5.40	−0.24	20.37	1.21	0.192	−0.007	181.99	4.23
8f	7.02	1.29	23.83	3.21	0.157	0.010	177.63	7.52
9	3.69	0.61	13.26	−0.55	0.136	−0.025	120.35	6.46
10	4.72	−0.66	18.91	3.22	0.182	−0.010	172.06	16.19
11g	3.79	−1.08	15.99	−0.53	0.166	0.008	153.10	6.39
12h	6.02	0.28	23.71	3.48	0.203	0.009	223.19	30.23
13	4.60	−0.51	21.20	0.09	0.187	0.010	184.86	6.91
14d	4.71	0.32	17.93	0.67	0.203	−0.012	137.27	− 1.81
15	4.30	0.60	19.84	1.09	0.275	0.053	135.71	−37.14
16	2.80	0.06	19.06	4.27	0.221	0.050	117.98	−24.03
17i	3.12	−0.44	11.27	−6.84	0.120	−0.025	89.92	−53.43
18h	6.09	0.55	27.24	4.36	0.295	0.057	216.17	18.98
19e	5.13	0.25	18.32	1.38	0.189	0.036	149.44	− 1.87
20a	5.79	1.65	19.02	1.71	0.199	0.041	151.47	5.70
21	6.44	−0.16	17.49	−3.07	0.181	−0.007	152.73	− 7.77
22	4.61	0.44	14.58	−1.23	0.200	−0.010	134.45	− 7.63
23g	3.89	0.24	18.24	1.68	0.204	0.032	161.57	6.31
24	3.35	−0.21	16.04	0.27	0.173	0.043	137.73	− 0.51
26h	6.88	0.71	26.82	3.49	0.186	0.037	201.15	33.91
27j	5.78	0.85	27.69	4.60	0.227	−0.007	201.24	36.70
28k	5.86	0.68	25.97	3.52	0.241	0.014	183.14	25.57
29b	5.05	−0.08	19.86	0.89	0.150	0.020	156.42	− 6.60
30a	3.29	−0.23	17.73	3.15	0.134	−0.007	112.29	−13.64
31i	2.60	−0.14	15.26	−1.12	0.105	−0.017	116.03	1.50
32c	5.08	0.89	23.04	5.23	0.234	0.035	207.96	30.92
33l	4.15	0.52	17.49	3.46	0.167	0.045	143.79	21.01
34m	3.89	−0.18	19.41	1.43	0.182	0.020	168.61	10.18
35n	4.54	0.56	18.23	1.79	0.203	0.020	166.15	10.71
36	6.38	1.46	22.37	3.55	0.205	0.034	181.00	43.01
37o	7.60	2.15	27.38	3.66	0.312	0.112	214.57	36.81
38p	3.33	−0.41	22.07	1.91	0.293	0.039	199.11	18.93
39q	4.14	−0.05	19.03	4.66	0.199	−0.029	164.12	− 5.98
40f	7.82	0.63	23.99	1.87	0.174	0.074	196.32	9.63
41	6.85	−0.08	23.70	0.65	0.210	0.065	200.93	7.29
42	5.79	−0.30	20.07	1.02	0.169	0.002	176.76	20.07
43	6.25	0.89	19.76	1.59	0.148	0.017	175.04	14.02
44	7.89	0.77	25.78	2.19	0.160	0.021	178.26	14.91
45	7.95	0.82	25.39	2.52	0.265	0.068	175.99	20.39
46	9.93	1.49	25.19	3.67	0.204	0.018	169.15	37.11
47	4.73	−0.83	18.40	1.48	0.188	−0.003	128.99	3.55
48	4.43	−1.60	20.63	2.38	0.241	0.042	145.33	16.40
49	6.59	0.07	26.99	2.27	0.224	0.031	235.61	32.29

APPENDIX

Subject No.[1]	Calcium		Phosphorus		Iron		Nitrogen	
	Intake	Retention	Intake	Retention	Intake	Retention	Intake	Retention
	mg./cm.	*mg./cm.*	*mg./kg.*	*mg./kg.*	*mg./kg.*	*mg./kg.*	*mg./kg.*	*mg./kg.*
50	3.71	0.23	17.33	−0.02	0.163	0.012	162.70	4.04
51	5.41	0.41	18.89	1.21	0.169	0.019	182.99	28.25
52	5.53	−0.41	22.38	1.40	0.150	−0.004	210.30	− 3.73
53	5.42	0.02	22.39	2.55	0.225	0.020	181.37	20.34
54a	4.14	0.05	15.21	0.12	0.200	0.061	136.19	− 0.69
55	4.22	−0.19	15.46	−0.92	0.265	0.061	163.94	13.86
56	4.07	0.14	13.49	−2.27	0.233	0.082	140.34	13.33
57j	4.86	0.17	21.35	0.41	0.227	−0.030	188.57	15.31
58k	4.50	0.27	18.75	−1.22	0.217	0.012	161.03	8.17
59p	3.39	−0.12	16.85	−1.34	0.214	0.049	158.10	− 4.75
60q	4.46	−0.45	19.98	−2.08	0.133	−0.038	129.24	−65.47
61	5.56	−0.04	24.40	0.11	....	....	183.59	22.47
62h	6.85	0.81	25.05	3.58	0.209	0.077	200.56	31.45
63c	4.52	0.46	17.32	−0.33	0.146	−0.005	163.39	13.30
64l	4.15	0.10	12.69	−1.99	0.129	0.047	115.86	− 2.27
65m	4.30	0.29	13.39	−4.97	0.175	0.054	142.01	−14.93
66n	4.92	0.03	15.68	−2.04	0.175	0.052	152.83	7.66
67	5.43	−0.14	21.46	0.14	0.197	0.064	185.77	21.84
68i	2.49	−0.58	10.68	−4.12	0.161	0.027	89.37	−26.89
69o	6.79	0.96	21.30	1.63	0.145	0.067	180.19	33.20
70g	6.49	0.02	18.77	−3.81	0.182	−0.015	191.50	29.66
71f	6.33	−0.01	22.24	1.66	0.180	0.063	173.59	21.67
72	5.92	−0.19	20.57	−8.15	0.216	0.042	210.92	34.70
73m	6.28	0.70	13.45	−6.42	0.172	−0.001	186.98	24.13
74o	7.33	−0.74	16.55	−6.86	0.145	0.034	221.18	43.73
75	...	...	13.75	−9.60	0.147	−0.042	215.57	44.51
76	9.35	−0.06	17.76	−4.48	0.153	0.029	161.02	− 7.35
77	6.85	−1.00	16.83	−4.02	0.138	0.017	205.38	14.49
78q	3.05	−3.01	16.14	−9.44	0.197	−0.011	202.47	20.00
79	3.75	−0.29	16.51	0.82	0.164	0.013	176.65	28.02
80	4.04	−0.44	20.85	−1.03	0.245	0.070	213.01	13.59
81	6.85	−0.08	24.23	−1.38	0.177	0.004	171.65	− 8.86
82e	6.09	0.89	20.64	3.15	0.159	0.029	151.45	− 4.45
83	3.65	0.08	17.51	0.02	0.183	0.025	197.94	16.08
84	...	...	12.84	−2.22	0.137	−0.017	144.69	−19.18
85	5.54	−1.00	11.31	−5.06	0.179	0.023	146.87	− 1.41
86	4.74	−0.39	16.23	0.04	0.143	0.010	143.50	2.09
87	7.02	0.29	27.59	5.20	0.210	0.034	224.26	18.38
88	4.30	−2.03	18.10	−1.69	0.173	0.034	204.97	11.90
89	6.92	2.32	24.71	5.70	0.141	0.071	180.29	35.30
90	10.17	0.08	32.37	4.41	0.137	0.035	213.62	40.68
91	5.41	0.80	20.33	9.85	0.134	0.002	166.78	38.04
92	3.81	−2.08	15.09	0.57	0.118	0.010	149.83	− 2.43
93	4.81	1.11	19.27	6.16	0.248	0.105	184.28	− 0.65
94	3.24	−0.19	15.74	1.84	0.151	0.016	151.14	8.06
95	3.25	−1.21	17.84	−1.17	0.189	0.019	192.19	15.11
96	6.71	0.74	26.99	4.82	0.164	0.037	213.18	25.80
97	4.67	0.51	18.38	2.45	0.256	0.090	179.48	36.75
98	3.00	−0.11	16.19	−0.58	0.229	0.024	160.32	2.40
99	4.90	−0.09	19.95	6.88	0.201	0.024	161.98	13.42
100	5.31	−1.80	19.60	−3.16	0.201	0.016	163.33	− 3.39
101o	6.80	0.87	25.55	4.29	0.116	0.015	181.68	24.76
Average	5.25	0.09	19.44	0.58	0.186	0.024	169.40	10.70

[1] Subscript letter is used to designate a subject studied more than once; for example Nos. 1a, 20a, 30a, 54a were the same person.

APPENDIX

TABLE III.—*Average daily intake and retention of calcium, phosphorus, iron, and nitrogen of subjects studied more than once.*

Subject	Calcium		Phosphorus		Iron		Nitrogen	
	Intake	Retention	Intake	Retention	Intake	Retention	Intake	Retention
	g.	*g.*	*g.*	*g.*	*mg.*	*mg.*	*g.*	*g.*
3b	0.908	0.152	1.019	−0.035	9.56	0.56	8.77	0.19
29b	0.840	−0.014	1.144	0.051	8.62	1.13	9.01	−0.38
Av.	0.874	0.069	1.081	0.008	9.09	0.84	8.89	−0.10
5d	0.948	−0.009	1.123	0.050	9.56	0.56	9.73	1.05
14d	0.772	0.053	1.092	0.041	12.38	−0.71	8.36	−0.11
Av.	0.860	0.022	1.107	0.045	10.97	−0.08	9.05	0.48
27j	0.940	0.139	1.343	0.223	10.99	−0.32	9.76	1.78
57j	0.791	0.027	1.046	0.020	11.14	−1.49	9.24	0.75
Av.	0.865	0.082	1.195	0.122	11.07	−0.90	9.50	1.27
28k	0.960	0.111	1.371	0.186	12.73	0.73	9.67	1.35
58k	0.737	0.045	0.986	−0.064	11.43	0.63	8.47	0.43
Av.	0.849	0.078	1.179	0.062	12.08	0.68	9.07	0.89
33l	0.674	0.085	1.182	0.234	11.31	3.02	9.72	1.42
64l	0.674	0.017	0.840	−0.132	8.55	3.12	7.67	−0.15
Av.	0.674	0.051	1.011	0.051	9.93	3.07	8.69	0.63
35n	0.773	0.096	1.174	0.115	13.07	1.30	10.70	0.69
66n	0.838	0.006	1.024	−0.133	11.43	3.37	9.98	0.50
Av.	0.805	0.050	1.099	−0.009	12.25	2.34	10.34	0.59
38p	0.542	−0.066	0.991	0.086	13.16	1.73	8.94	0.85
59p	0.552	−0.019	0.780	−0.062	9.91	2.25	7.32	−0.22
Av.	0.547	−0.042	0.885	0.012	11.53	1.98	8.13	0.32
4c	1.021	0.250	1.162	0.197	10.20	0.05	10.44	1.79
32c	0.823	0.145	1.274	0.289	12.92	1.93	11.50	1.71
63c	0.732	0.074	0.951	−0.018	8.03	−0.26	8.97	0.73
Av.	0.859	0.157	1.129	0.156	10.38	0.57	10.30	1.41
7e	0.891	−0.039	1.108	0.066	10.46	−0.39	9.90	0.23
19e	0.846	0.042	0.982	0.074	10.14	1.91	8.01	−0.10
82e	1.025	0.149	1.067	0.163	8.23	1.49	7.83	−0.23
Av.	0.921	0.051	1.052	0.101	9.61	1.00	8.58	−0.03
8f	1.141	0.209	1.268	0.171	8.37	0.53	9.45	0.40
40f	1.272	0.103	1.370	0.107	9.92	4.21	11.21	0.55
71f	1.037	−0.001	1.221	0.091	9.89	3.49	9.53	1.19
Av.	1.150	0.104	1.286	0.123	9.39	2.74	10.06	0.71
11g	0.625	−0.178	0.876	−0.029	9.09	0.46	8.39	0.35
23g	0.643	0.039	0.954	0.088	10.67	1.67	8.45	0.33
70g	1.068	0.004	1.038	−0.211	10.06	−0.80	10.59	1.64
Av.	0.779	−0.044	0.956	−0.051	9.94	0.44	9.14	0.77
17i	0.527	−0.075	0.738	−0.448	7.89	−1.65	5.89	−3.50
31i	0.440	−0.024	0.914	−0.067	6.29	−1.02	6.95	0.09
68i	0.421	−0.098	0.663	−0.256	10.03	1.69	5.55	−1.67
Av.	0.463	−0.065	0.772	−0.257	8.07	−0.33	6.13	−1.69

APPENDIX

Subject	Calcium		Phosphorus		Iron		Nitrogen	
	Intake	Retention	Intake	Retention	Intake	Retention	Intake	Retention
	g.	*g.*	*g.*	*g.*	*mg.*	*mg.*	*g.*	*g.*
34m	0.618	−0.029	1.163	0.086	10.89	1.23	10.10	0.61
65m	0.683	0.046	0.771	−0.286	10.10	3.13	8.18	−0.86
73m	0.997	0.111	0.773	−0.370	9.91	−0.06	10.77	1.39
Av.	0.766	0.043	0.903	−0.190	10.30	1.43	9.68	0.38
39q	0.631	−0.008	0.923	0.226	9.65	−1.41	7.96	−0.29
60q	0.686	−0.069	0.943	−0.098	6.29	−1.77	6.10	−3.09
78q	0.469	−0.463	0.783	−0.458	9.56	−0.55	9.82	0.97
Av.	0.595	−0.180	0.883	−0.110	8.50	−1.24	7.96	−0.80
1a	0.539	0.017	0.732	−0.038	9.77	0.57	6.92	−0.59
20a	0.934	0.266	1.168	0.105	12.21	2.51	9.30	0.35
30a	0.530	−0.038	1.053	0.187	7.97	−0.43	6.67	−0.81
54a	0.668	0.008	0.887	0.007	11.65	3.54	7.94	−0.04
Av.	0.668	0.063	0.960	0.065	10.40	1.55	7.71	−0.27
12h	1.015	0.048	1.247	0.183	10.69	0.49	11.74	1.59
18h	1.027	0.092	1.449	0.232	15.70	3.05	11.50	1.01
26h	1.160	0.120	1.400	0.182	9.71	1.94	10.50	1.77
62h	1.157	0.137	1.330	0.190	11.08	4.11	10.65	1.67
Av.	1.090	0.099	1.357	0.197	11.79	2.39	11.10	1.51
37o	1.213	0.343	1.391	0.186	15.87	5.70	10.90	1.87
69o	1.083	0.154	1.097	0.084	7.47	3.47	9.28	1.71
74o	1.169	−0.118	0.844	−0.350	7.41	1.75	11.28	2.23
101o	1.084	0.138	1.311	0.220	5.94	0.77	9.32	1.27
Av.	1.137	0.129	1.161	0.035	9.17	2.92	10.19	1.76