A SEVEN-DAY STUDY OF ENERGY INTAKE AND NITROGEN, CALCIUM, AND PHOSPHORUS RETENTION OF TWO 17-YEAR OLD COLLEGE WOMEN

by

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B. S., Kansas State College of
Agriculture and Applied Science, 1931

A THESIS

submitted in partial fulfillment of the

requirements for the degree of

MASTER OF SCIENCE

Department of Food Economics and Nutrition

KANSAS STATE COLLEGE
OF AGRICULTURE AND APPLIED SCIENCE

1940

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INTRODUCTION

Much interest is being manifested in the energy intake of college women. It is thought that the modern young woman, in an attempt to secure a fashionable figure, consumes fewer calories than did her predecessor of a few years ago. Some doubts exist as to whether the total energy consumed is sufficient to carry on moderate activity in addition to the basal metabolic processes. If it is, then the present energy standards for subjects of this age may be regarded as too high.

Nitrogen, calcium, and phosphorus are important constituents of the human body. About three per cent of the total body weight is nitrogen, while 1.5 per cent is calcium and one per cent is phosphorus. All are essential in the building of body tissues and in regulation of body processes. It is therefore regarded as desirable that throughout the entire period of growth, these elements be supplied, not only in adequate, but in optimal amounts.

With lowered caloric intakes, it is reasonable to suppose that in some cases at least the consumption of protein, calcium, and phosphorus is also lowered. It is

probable that the amounts of these substances ingested may fall below even adult standards, which have been generally accepted as adequate for women of college age. However, the results of a few recent balance experiments appear to indicate that these standards may be too low for the younger members of this group. This is evidenced by retention of these elements on generous diets and by negative balances on more restricted ones.

Ohlson, Nelson, and Swanson (1937) summarized this situation with the statement "Facts concerning scope and character of postpubescent growth and early adult maturation and attendant dietary needs are almost entirely lacking. Those available are based largely on studies of adults and of clinical material."

A balance study is recognized as the best available way to determine the body's needs for certain elements. Sherman (1937) stated, "We can expect reliable data on phosphorus requirements from those experiments only in which the amounts of phosphorus are actually determined in food, feces, and urine." The same statement may be applied equally well to nitrogen and calcium.

To contribute some information on consumption and utilization of food by college women, a seven-day study

was made of the energy intakes and the nitrogen, calcium, and phosphorus balances of two 17-year old freshman women who ate a freely-chosen diet. This investigation was undertaken as part of a regional project in which an attempt is being made to determine the nutritional status of college women. The information obtained, combined with results of similar studies, should eventually make it possible to evaluate the standards now in use and perhaps to set up new and more desirable ones for the future.

REVIEW OF LITERATURE

Chaney and Ahlborn (1939) suggested that "One of the desirable means of promoting health is the consumption of a diet adequate as to kind as well as amount of food." According to Hawley (1932), "To ascertain the adequacy of a diet, the food constituents are compared with a standard of good nutrition. A standard proposed by Sherman is most commonly used. It suggests the need of 3000 Calories, 67 gm. of protein, 0.68 gm. of calcium, and 1.3 gm. of phosphorus per man per day."

Sherman (1937) examined the available literature and found 109 experiments upon adults in which the nitrogen

balance showed sufficient approach to equilibrium to make it appear that the total output of nitrogen might be taken as an indication of the protein requirement. This daily output of total nitrogen, calculated as protein and it in turn to a basis of 70 kg. of body weight, ranged between 21 and 65 gm. per day and averaged 44.4 gm. per 70 kg. of body weight.

Compiling data on calcium, Sherman (1920 b) found a daily range in intake varying from 0.27 to 0.82 gm. and an average of 0.45 gm. of calcium per 70 kg. of body weight. A similar study of 95 phosphorus balances gave values ranging from 0.52 to 1.20 gm. daily and averaging 0.88 gm. per 70 kg. of body weight. As a result of these studies, Sherman (1920 a) suggested as the daily requirements of a 70-kg. man, 0.45 gm. of calcium and 0.88 gm. of phosphorus.

To allow for the variations likely to be encountered in everyday foods, and to safeguard those persons whose requirements are higher than average, Sherman in formulating dietary standards suggested adding 50 per cent as a margin of safety to the average minimal requirements. These additions bring the allowance for acceptable diets to one gram of protein per kg. body weight, and 0.68 gm. of calcium, and 1.32 gm. of phosphorus per 70-kg. per day.

MacLeod and Griggs (1918), using the inventory method, made a dietary study at Vassar College. The nutritive value of the diets was calculated from tables of food composition. While these workers had previously determined the mean per capita requirements to be between 1900 and 2000 Calories per day, they found the average food consumption was actually much higher, amounting to 2698 Calories per person per day. This estimate did not include between-meal eating, which in some cases reached the high level of 1500 Calories daily.

An eight-day dietary study was conducted in a women's residence hall at Montana State College by Borthwick (1917). Her results showed an average per capita consumption of 2549 Calories and 73 gm. of protein daily.

Blunt and Bauer (1922) investigated the basal metabolism and food consumption of 19 college women who were considered underweight by insurance standards. They found the basal rate to be almost normal. However, ten subjects ate fewer than 1800 Calories per day, 16 less than 2000 Calories, and only two ate more than 2200 Calories daily. With 11 subjects the intake was only about 500 Calories above the basal requirement and one actually ate an amount insufficient to meet her basal needs. This meant that the mean food consumption for the group was low. It averaged

1830 total Calories or 37.3 Calories per kilo of body weight per day.

A month's survey of the food consumption of 20 organizations feeding 465 college students was reported by Kramer and Grundmeier (1926). The daily energy intake ranged from 1856 to 3761 with an average of 2889 Calories per capita. The diets furnished a mean of 85 gm. of protein per 3000 Calories. These groups consumed daily per person 0.578 gm. of calcium and 1.242 gm. of phosphorus. The calcium intake was considered to be inadequate for 70 per cent of the group and the phosphorus inadequate for 75 per cent.

Conard (1930) used the inventory method in making a study of the nutritive value of the food consumed by the women living in a college sorority group. Her results indicated an average consumption per capita per day of 2055 Calories, 58.1 gm. of protein, 0.50 gm. of calcium, and 0.92 gm. of phosphorus. These were all, with the exception of protein, below the standards suggested by Sherman.

Ryder (1931) computed the nutritive value of the food served to a group of college women living in a residence hall at Kansas State College. She used the inventory method to determine the amounts eaten and collected and

analyzed all edible waste, correcting for the same. She found the average per capita energy intake to be 1821 Calories per day which was low when compared with the calculated requirement of 2494 Calories based on the mean weight and activity of these subjects. The protein consumed was slightly low, averaging 56.1 gm. per day as compared with a requirement of 57.1 gm. The calcium and phosphorus were above the calculated needs, the calcium averaging 0.790 gm. and the phosphorus 1.197 gm. as compared with 0.567 and 1.111 gm., respectively, which were the amounts believed to be necessary.

In a dietary study of 18 normal college women, Coons and Schiefelbusch (1932) found that the daily energy intake ranged from 29 to 40 Calories per kg. of body weight with an average of 35 Calories per kg. or a total of 1990 Calories per person. The protein consumption was considered normal, being 1.1 gm. per kg. or 56 gm. per capita per day. The calcium averaged 0.930 and the phosphorus 1.191 gm. per day. The subjects most underweight had the lowest mineral and protein intakes.

A dietary study of the inventory type was made by Shirley (1932) of ten organized Kansas State College groups to secure information regarding the nature of the food

eaten by college students. The groups included six fraternities and four sororities. An average of 2822 Calories, 86.4 gm. of protein, 0.78 gm. of calcium and 1.38 gm. of phosphorus were found to be consumed daily by the women of these groups, but no account was taken of edible waste.

Kramer, Evers, Fletcher, and Gallemore (1934) reported the protein, calcium, and phosphorus intakes of 25 college women eating a freely-chosen diet as indicated by nitrogen, calcium, and phosphorus outputs. The study covered two periods of four days each, one in the fall and the other in the winter. In no case was the daily protein consumption below Sherman's requirement, but only seven subjects had intakes above the standard of one gm. per kg. of body weight. The protein per 70 kg. per day averaged 62.8 gm. for the fall and 60.7 gm. for the winter period. Calcium per 70 kg. per day averaged well above the Sherman standard of 0.68 gm., being 1.04 and 1.11 gm. for the fall and winter periods respectively. However, some subjects had intakes below the standard and one was below the requirement. Daily phosphorus intakes were found to be 1.39 gm. per 70 kg. for the fall and 1.40 gm. for the winter period, both averages being above the standard of 1.32 gm.,

although some subjects consumed amounts below the standard.

The purpose of a study by Jackson (1934) was to determine the actual food consumption in a sorority by deducting the waste, both edible and inedible, from the total food purchased. Under these conditions, the daily average per capita consumption was 2338 Calories, 63.3 gm. of protein, 0.53 gm. of calcium and 0.977 gm. of phosphorus. The individual requirements for this group, calculated from Sherman standards on the basis of average weight, were 2284 Calories, 51 gm. of protein, 0.517 gm. of calcium, and 1.000 gm. of phosphorus. A comparison between the requirement and the actual intake indicated that the consumption was above the standard for energy, protein, and calcium, and slightly below for phosphorus.

The nutritive value of the food consumed by a cooperative group of college women living in a residence hall, as determined by a dietary study of the inventory type, was reported by Schermerhorn (1936). The study covered 14 days and 133 persons served as subjects. The average individual requirements were calculated to be 2549 Calories, 60.5 gm. of protein, 0.59 gm. of calcium, and 1.14 gm. of phosphorus, while the actual intakes were 2088 Calories, 65.0 gm. of protein, 0.75 gm. of calcium and 1.13 gm. of phosphorus.

Wheeler and Mallay (1936) determined the nutritive value of the food purchased by 28 women living in Blodgett Hall at Vassar College in 1933-1934. The total intake per person per day averaged 70 gm. of protein, 0.92 gm. of calcium and 1.32 gm. of phosphorus. As the mean weight of the group studied was 56.6 kg., the protein intake averaged more than the one gm. per kg. recommended by Sherman.

Two senior women at Kansas State College served as subjects for a study of energy and protein intakes (Cox, 1937). A standard of 2400 total Calories or 42.9 Calories per kg. has been set as the normal energy requirement of a 56-kilo woman of moderate activity (Sherman, 1937). Both subjects of this investigation consumed fewer Calories than the standard required, having a mean daily intake of 1840. The protein eaten was sufficient according to Sherman, as it averaged, respectively, 1.2 and 1.1 gm. per kg. of body weight.

A study by Chen (1938) of the calcium and phosphorus intakes of two young college women eating a freely-chosen diet showed that these subjects consumed greater amounts of these elements over an eight-week period than Sherman recommended for adults. This work indicated that larger

amounts of calcium and phosphorus than are commonly recommended may be desirable for this age group. Subject A consumed 0.623 gm. of calcium or 12.90 mg. per kg. per day and 0.996 gm. of phosphorus which furnished 20.63 mg. per kg. Subject L consumed 0.651 gm. of calcium, which also supplied 12.94 mg. per kg. This subject ingested slightly more phosphorus than Subject A, her total intake being 1.063 gm. or 21.13 mg. per kg. daily.

Kramer and Gillum (1938) investigated animal products as sources of protein, calcium, and phosphorus in the human diet. Urine and feces were collected by 25 college women for a four-day period while following their customary food habits. The outputs of nitrogen, calcium, and phosphorus, which, when corrected for losses in digestion, were believed to be indicative of nitrogen, calcium, and phosphorus intakes, were calculated for purposes of comparison to the common basis of 70 kg. of body weight. No subjects showed protein intakes below the requirement suggested by Sherman for adult human maintenance, but the majority were below the standard he recommended. All but three subjects consumed calcium in amounts above the standard; however, two had phosphorus intakes below the

requirement and only about one-third equaled or exceeded the standard.

Goddard and Morgan (1938), investigating the results of balance experiments for adequacy of the protein in the diets of a group of selected senior and graduate students, found the average daily per capita intake was 61.9 gm. for women and 77.0 gm. for men. Another study by these same workers of eight students whose habitual diets were low in protein (0.6 to 0.9 gm. per kg.) revealed no definite abnormalities. The albumin-globulin ratios of the blood serum were all within normal range although the basal metabolic rates were low. A group of three, serving as controls, ingested an average of 1.23 gm. of protein per kg. per day.

As part of a personal dietary study during weight reduction, Reeve (1939), while eating her regular diet preliminary to the reducing regime, performed a seven-day nitrogen, calcium, and phosphorus balance on herself and measured her caloric intake. The diet supplied a mean of 2006 or 28.2 Calories per kg. per day and 50.4 gm. of protein or 0.71 gm. per kg. daily. The subject was in negative balance for nitrogen and calcium, while the phosphorus was slightly positive, on an intake of 1.034 gm. of

calcium and 1.576 gm. of phosphorus daily, amounts which are ordinarily considered generous.

Shepek (1939) found a mean daily phosphorus retention of 5 mg. per kg. of body weight for four college women over an eight-week period. The daily individual phosphorus intakes for the four subjects were 1.338, 1.325, 1.162, and 1.313 gm., respectively. The results of this study suggested that these women, when allowed to choose their diets, consumed even larger amounts of phosphorus than are commonly recommended for the 70-kg. adult make unit.

A study of one week's dietary for 100 Utah State Agricultural College women students representing groups eating in different places was made by Morris and Bowers (1939). Using Rose's standard for Calories, and Sherman's for protein, calcium, and phosphorus, it was found that the diets of all the groups were lower in energy and phosphorus and higher in protein and calcium than the standards used for comparison. The mean daily intake for all the groups was 1805±44.5 Calories, 60.71±1.71 gm. of protein, 0.717±0.036 gm. of calcium and 1.103±0.053 gm. of phosphorus, while the calculated per capita need based upon the above standards was 2245 Calories, 56.18 gm. of protein, 0.680 gm. of calcium, and 1.32 gm. of phosphorus.

Booher (1940), after investigating the diets of industrial workers, reached the conclusion that "the freely-chosen diets of individuals vary so widely in combinations of proteins, it is important to allow a liberal margin of safety on protein intake, hoping thereby to secure adequate amounts of all the essential amino acids." She further stated that many authorities have accepted a daily allowance of one gm. of protein per kg. of body weight as probably representing a reasonable margin of safety for the protein needs of adults; but others tend to regard this quantity as "not liberal" at least. Leitch, according to Booher, presented a re-evaluation of the results dealing with nitrogen balances and concluded that the allowance should be about 80 gm. daily per 70 kg. of body weight in order to provide a 50 per cent margin of safety. McCollum et al. (1939) have recommended as the adult daily standard for protein an amount varying from 110-120 gm.

PROCEDURE

Two 17-year old freshman women enrolled in Home Economics at Kansas State College served as subjects for this seven-day metabolism study. They were both regarded

as normal in health as determined by a medical examination and a basal metabolism test.

The nude weight was taken on bathroom scales each morning upon rising. Body weight, the number of hours of sleep each night, the type of activity followed on the previous day, and any unusual occurrence, as a cold or constipation, were recorded daily. The 24-hour day began at 12 o'clock, noon.

Tap water was used by the subjects and records of the total intake for each day were obtained. A weighed amount more than sufficient for a day's supply was bottled and placed in each subject's room. At the end of the day, the weight of that remaining was deducted from the original amount to determine the quantity used. Additional water drunk at meal times was also weighed. When the subjects drank from fountains, they measured the amount in a cup and the weight was estimated from the mean of six preliminary weighings for that same approximate amount.

The food was prepared in quantities sufficient to serve a group of six and served in family style. Each subject was permitted to help herself to the kind and amount of the available food desired, and to subsequent servings, if she wished them. The individual servings

were weighed on a Hanson platform scale of either 500- or 1000-gm. capacity according to the size of the serving. At the end of the meal, any food uneaten was weighed and the amount subtracted from that of the original serving to obtain the exact quantity eaten. Exceptions were made in the case of butter, sugar, and jelly which were weighed in quantities more than sufficient for one day's supply. That remaining at the end of the three meals was deducted from the amount served.

Approximately one-fifth of the weight of each food eaten by a subject was set aside, and as soon as possible after the meal, two aliquots, each representing one-tenth of the portion eaten, were weighed and preserved for chemical analysis. To facilitate the handling and analysis of the samples, the butter aliquots were placed in separate containers. The necessity for two food aliquots arose from the fact, that to secure the energy intake, it was necessary to prepare a dried food sample for burning in the oxy-calorimeter.

The daily food aliquots were made into weekly composites. At the beginning of the experiment, one of the aliquots for each subject was placed in a weighed evaporating dish, a drop of formaldehyde added to prevent spoilage,

then the whole placed in an oven and dried in air at a temperature of 50-60° C., which permitted drying without charring. Each day's portion was added until the weekly composite was complete, the sample being dried continuously from the beginning until the weight of the complete dried sample was practically constant. The dried composite was ground, first in a food chopper using blades of increasing fineness, then with mortar and pestle, and finally put through sieves of various sizes until all of the material had passed through a 20-mesh screen. This insured a finely divided, uniform product. The sample was then placed in a glass stoppered bottle and stored at room temperature.

An acid digest was made of the other food aliquots. The daily samples for a subject were combined in a 3-liter Erlenmeyer flask, 100 ml. of C. P. hydrochloric acid (HCl) were added with sufficient distilled water to permit the contents to rotate freely. The mixture was stored in a refrigerator until the composite was complete for the week. It was then placed on an asbestos covered hot plate which maintained a temperature below 250° C. and prevented charring of the sample. The heating was continued several hours until the suspension was of even consistency.

The mixture was then partially cooled and put through a sieve to insure breaking up of the cellulose. Previously the solids of one of the butter composites were separated from the butterfat by melting, settling, and decanting, then added to the week's food composite. The butterfat was discarded as it contained negligible amounts of nitrogen and minerals. The sifted digest was made up to a convenient volume with distilled water, usually 2000 ml., mixed thoroughly, and stored in a glass-stoppered bottle.

The menstrual period was avoided in choosing the time for the study. Complete collections of urine and feces were made during the seven-day period. Carmine or lampblack was used to mark the fecal periods. A capsule was taken one-half hour before the first meal of the period and another one-half hour preceding the first meal following the completion of the study. Feces were collected in tight, paraffined cardboard containers from the first day of the period until the marker appeared at the end of the experiment. Only the feces collected between the markers were retained. The daily fecal collections were combined for each subject to form a weekly composite which was made into an HCl digest as described for food.

The urine for each 24-hour day was collected in wide-

mouthed glass-top bottles to which toluol, sufficient to made a layer approximately one-eighth inch deep over the top, had been added for the purpose of preservation. The bladder was emptied just before the day was to begin and all urine passed after this time and until the same time the next day was retained, thus insuring complete 24-hour collections as nearly as possible. Creatinine determinations were made on each day's urine, an approximately constant value from day to day indicating that collection was complete. Aliquots, one-third of the daily urinary collections for subject O and one-fifth for subject B, were put into individual large glass-stoppered bottles, one for each subject, to form the week's composite. Each day 5 ml. of C. P. HCl were added to the contents to insure acidity, as nitrogen would have been lost if the mixture had become alkaline. The total volume, specific gravity, temperature, and reaction to litmus were recorded each day.

After the collections were complete and all samples had been prepared for chemical analysis, they were analyzed for nitrogen, calcium, and phosphorus, and the caloric value of the butter and dry food samples determined. All analyses were made at least in triplicate and

in greater number if necessary to insure correct results. Accuracy of technique was proved by analysis of materials of known composition.

The Kjeldahl method, as modified by Gunning, and reported by the Association of Official Agricultural Chemists (A. O. A. C., 1935) was used for the determination of nitrogen.

Calcium was determined volumetrically by a modified A. O. A. C. macro method (1935).

Phosphorus was obtained gravimetrically by the Neumann method (1903) as modified by Lundell and Hoffman (1923) and McCandless and Burton (1924).

The caloric consumption of each of the subjects was determined by burning samples of the dried food and the butter in the oxy-calorimeter originated by Benedict and Fox (1925 a, 1925 b).

DISCUSSION OF RESULTS

Personal data for each subject, including height, weight, amount of sleep per day, and results of the basal metabolism tests appear in Table 1.

Menus for each subject for the seven days of this

experiment are shown in Tables 2 and 3. Subject O, weighing 67.3 kg., consumed much larger amounts of many foods than Subject B who weighed 56.0 kg. (Table 4). In spite of the larger total food intake, Subject O consumed foods containing a smaller amount of cellulose than did Subject B when the fiber content of the two diets was calculated according to Chaney and Ahlborn (1939). Her mean daily fiber intake was only 6.53 gm. while that for Subject B was 7.22 gm. As was to be expected from a comparison of the amount of fiber eaten, the fecal collections of Subject O were smaller than those of Subject B, averaging 84.0 and 95.5 gm. per day, respectively. There was a slight tendency toward constipation in Subject O, although, according to Chaney and Ahlborn (1939), a diet containing 6.3 gm. fiber per day per 70-kg. of body weight should be sufficiently laxative. It is possible that had the foods been analyzed for fiber, they might have shown a lower value. It is also possible that this particular subject needed a larger amount of cellulose than the average individual.

Table 1. Personal data.

Subject	O	B
Class	Freshman	Freshman
Course in college	Home Economics	Home Economics
Age in years to nearest birthday	17	17
Height in cm.	179	142
Weight in kg. Range	66.8-67.7	54.5-56.8
Mean	67.3	56.0
Loss during experiment	0.0	0.45
Type of build	Average	Average
Basal metabolic rate in per cent compared to the DuBois standard	-15.61	-3.18
Health	Normal	Normal
Activity	Active	Moderate
Average hours of sleep per day	7	7 1/4

Table 2. Menus for Subject O arranged in order of beginning of day.

Day	Luncheon	Dinner	Breakfast	Between meals
1	Macaroni and cheese Cabbage slaw Bread Butter Brownies Canned pineapple	Salmon salad Eggplant casserole Harvard beets Rolls Cottage cheese Apple pie	Pineapple juice Grapenuts Cream Sugar Toast Butter Honey	Soda crackers Oranges
2	Salmon salad Cottage cheese Beets Rolls Butter Jelly Cocoanut macaroons Fruit cup	Bacon and rice Red-hot apples Rolls Jello fruit salad Cake	Oranges Grapenuts Cream Sugar Toast Milk	
3	Chicken Potatoes Gravy Gelatin fruit salad Bread Butter Jelly Cake Whipped cream	Fried chicken Tomatoes Bread Butter Gelatin salad Cake Whipped cream	Banana Grapenuts Cream Sugar Toast Roll Butter Jelly	Cookies Candy Peanuts
4	Toasted cheese sandwiches Buttered corn Cabbage slaw Bread Butter Jelly Red-hot apple Cake	Liver Buttered corn Harvard beets Carrot strips Cornbread Butter Honey Lemon custard cup	Oranges Rolled oats Cream Sugar Hard-cooked eggs Toast Jelly Butter	
5	Tomato soup Crackers Devilled eggs Bread Butter Jelly Prunes Doughnuts	Meat loaf Macaroni salad Harvard beets Buttered peas Bread Butter Jelly Banana cream pie	Prunes Cereal Cream Sugar Toast Butter Jelly Milk	
6	Chicken soup with rice Croutons Combination salad Banana cream pudding	Meat soufflé Glazed sweet potatoes Tomato and cottage cheese salad Bread Butter Jelly Jello Cake	Oranges Grapenuts Cream Sugar Scrambled eggs Toast Butter	
7	Fried potatoes Carrot and raisin salad Lettuce sandwich Grapes	Baked ham Scalloped potatoes Green beans Sliced tomatoes Peaches Cake Cookies	Oranges Grapenuts Cream Sugar Bacon Fried egg Toast Butter	Crackers

Table 3. Menus for Subject B arranged in order of beginning of day.

Day	Luncheon	Dinner	Breakfast	Between meals
1	Fried potatoes Carrot and raisin salad Lettuce sandwich Grapes	Baked ham Scalloped potatoes Green beans Sliced tomatoes Bread Butter Peaches Cake Cookies	Oranges Shredded wheat Cream Sugar	Coca-cola
2	Kidney bean salad Potatoes Green beans Bread Butter Cookies Apricots	Cabbage Creamed potatoes Lime-grape salad Muffins Butter Apple Betty Chocolate macaroons	Oranges Bacon Fried egg Muffin Butter	Coca-cola
3	Frankfurters Sauerkraut Peas Toasted cheese sandwiches Cocoanut cream pie	Bacon Waffles Butter Syrup Brown Betty	Apricots Shredded wheat Cream Sugar	Candy
4	Steak Mashed potatoes Lettuce salad Bread Butter Pickle Cake Ice cream Chocolate sauce	Devilled eggs Cheese sandwiches Cake	Tomato juice Shredded wheat Cream Sugar Toast Butter Jam	
5	Corned beef hash Peas Lettuce salad Bread Butter Jam Apple Betty	Creamed salmon Macaroni Stuffed peppers Buttered carrots Cabbage slaw Bread Butter Jam Canned pears	Oranges Grapenuts Cream Sugar Toast Butter Jam	
6	Baked eggs and bacon Macaroni salad Fried apples Bread Butter Jam Tapioca cream Chocolate cake	Cheese fondue Sweet potatoes Spiced apples Tomatoes Bread Butter Tapioca cream Cake	Oranges Shredded wheat Cream Sugar Toast Butter Jam	Coca-cola
7	Meat - gravy Sweet potatoes Peas Tomatoes Bread Butter Jam Peaches	Bacon Waffles Syrup Watermelon Cocoanut macaroons	Grapefruit Shredded wheat Cream Sugar Toast Butter Jam	

Table 4. Caloric intakes.

Subject	Intakes: Dry food other than visible fat		Intakes: Visible fat		Calories: From food other than visible fat	Calories: From visible fat	Calories: Total		Calories: Per kg. per day
	gm.	Cal. per gm.	gm.	Cal. per gm.	per wk.	per wk.	per wk.	per day	
O	4409	4.46	268.5	9.021	19,664	2422	22,086	3155	46.9
B	3134	4.12	239.0	9.264	12,912	2214	15,126	2161	38.6

The volume of the urine collections and the creatinine determinations for each subject each day are given in Table 5. Subject O excreted an average of 2045 ml. per day while the volume for Subject B was only 1003 ml. These totals paralleled closely the water intakes for each subject (Table 6).

As the volume of the urine increased, the specific gravity decreased, the temperature varying little from day to day at the times the specific gravity was obtained. When tested with litmus, the urine gave an acid reaction in all cases. The creatinine excretion was regarded as reasonably constant each day which indicated that urinary collections were complete.

The energy intakes for both subjects are stated in Table 4. Subject O consumed a mean of 3155 Calories daily while Subject B used only 2161 Calories. The large difference between these intakes seemingly can be accounted for by the fact that Subject O was much larger and was also more active than Subject B. It could not be explained by the basal metabolic rate as it was low for this Subject (Table 1).

Calculated on the basis of Calories per unit of weight, Subject O's intake averaged 46.9 and Subject B's, 38.6 Calories per kg. Compared with the accepted standard

Table 5. Daily urinary and creatinine outputs.

Day	Subject O		Subject B	
	Urine	Creatinine	Urine	Creatinine
	ml.	gm.	ml.	gm.
1	1390	1.538	2350	1.134
2	1910	1.480	990	1.115
3	2913	1.436	690	1.140
4	1525	1.232	735	1.072
5	2123	1.470	550	1.196
6	1596	1.549	756	1.136
7	2855	1.299	952	1.065
Mean	2045	1.429	1003	1.123

Table 6. Water intakes.

Day	Subject O		Subject B	
	ml.	Cups*	ml.	Cups*
1	1614	6.7	1335	5.6
2	1382	5.8	751	3.1
3	2173	9.1	1624	6.8
4	3906	16.3	1046	4.0
5	1916	8.0	1629	6.8
6	1932	8.1	1312	5.5
7	2608	10.9	1270	5.3
Mean	2218	9.2	1281	5.3

*Calculated on basis of 240 ml. to one cup.

of 2400 total Calories daily or 42.9 Calories per kg. for a 56-kg. woman of moderate activity, Subject O's intake was approximately nine per cent high, and Subject B's 10 per cent low. As Subject O maintained her weight, and during the seven days Subject B's weight ranged between one kilo above and one kilo below her average weight, it would seem that these subjects consumed sufficient Calories to meet their energy needs.

The nitrogen, c alcium, and phosphorus findings are included in Table 7. The protein intakes given in Table 8 were calculated by multiplying the gm. of nitrogen as determined by analysis by 6.25. With the exception of one case, both subjects had positive balances for all of the elements studied although they were much higher for Subject O on a higher intake.

The mean daily intake of protein for Subject O was 89.4 gm. or 1.328 gm. per kg. which was high compared with Sherman's adult standard of one gm. per kg. Subject B consumed only 55.3 gm. per day or 0.987 gm. per kg. which was slightly below the standard. Her lower protein intake can probably be explained by the fact that she disliked milk and did not consume it as a beverage. These findings are well within the limits of the amounts of protein that

most authorities believe should be included in an adequate diet for adults but below those recommended during the growing period.

As both subjects were in positive balance for nitrogen during the week of the study, they evidently were storing nitrogen in the body, probably indicating that not only was the protein being used to repair tissues and regulate body processes, but that growth was still taking place. On the other hand, nitrogen retention in these cases might have indicated replenishing of depleted reserves in the body. The time allowed for the study was not sufficient to permit of determining whether this condition existed.

The calcium balances in both cases approached equilibrium, that for Subject O being slightly positive and that for Subject B, slightly negative. As in the case of the low protein intake for Subject B, this negative balance was undoubtedly partly due to the lack of milk in her diet. Also it may have been affected by the lower protein consumption as Pittman and Kunerth (1939), working with college women, and Hawks (1938), working with children, found that with lower intakes of protein in the diet there was decreased retention of both calcium and phosphorus.

Table 7. Nitrogen, calcium, and phosphorus findings.

Subject	Intake			Output									Balance		
				Urine			Feces			Total					
	Per wk.	Per day	Per kg. per day	Per wk.	Per day	Per kg. per day	Per wk.	Per day	Per kg. per day	Per wk.	Per day	Per kg. per day	Per wk.	Per day	Per kg. per day
	gm.	gm.	mg.	gm.	gm.	mg.	gm.	gm.	mg.	gm.	gm.	mg.	gm.	gm.	mg.
Nitrogen															
0	100.10	14.30	212.5	75.41	10.78	161.2	10.57	1.51	22.4	85.98	12.29	183.6	+14.12	+2.01	+28.9
B	61.84	8.83	157.7	47.41	6.77	120.9	9.89	1.41	25.2	57.30	8.18	146.1	+ 4.54	+0.66	+11.8
Calcium															
0	6.08	0.87	12.9	1.25	0.18	2.7	4.61	0.66	9.8	5.86	0.84	12.5	+0.22	+0.03	+ 0.4
B	4.21	0.60	10.7	1.35	0.19	3.4	3.00	0.43	7.7	4.35	0.62	11.1	-0.14	-0.02	- 0.4
Phosphorus															
0	10.98	1.57	24.8	5.70	0.81	12.0	2.22	0.32	4.8	7.92	1.13	16.8	+3.06	+0.54	+ 8.0
B	7.29	1.04	18.6	3.97	0.57	10.2	2.49	0.36	6.4	6.46	0.93	16.6	+0.83	+0.11	+ 2.0

Table 8. Nitrogen and protein intakes.

Subject	Period		Day		Per kg. per day	
	Nitrogen	Protein	Nitrogen	Protein	Nitrogen	Protein
	gm.	gm.	gm.	gm.	mg.	gm.
0	100.10	625.6	14.30	89.4	212.5	1.328
B	61.84	386.5	8.84	55.3	157.9	0.987

Table 9. Summary of food intakes of Kansas State College women on freely-chosen diets.

Study	Date	Subjects: No.	Subjects: Mean weight	Calories: Total per day	Calories: Per kg. per day	Protein: gm. per day	Protein: mg. per kg. per day	Calcium: gm. per day	Calcium: mg. per kg. per day	Phosphorus: gm. per day	Phosphorus: mg. per kg. per day
			kg.								
Cox	1937	2	49.3	1840	37.3	59.6	1.21				
Chen	1938	2	49.3					0.637	12.9	1.030	20.9
Reeve	1939	1	71.0	2006	28.3	50.4	0.71	1.034	14.6	1.576	22.2
Shepek	1939	4	57.5							1.285	22.5
Pittman**	1938	4	57.5	2128	37.0	63.4	1.10	0.974	16.9		
Pittman**	1939	1	41.1			99.3	2.41	2.323	56.5	2.125	51.7
This study	1940	1	67.3	3155	46.9	89.4	1.33	0.870	12.9	1.570	24.8
This study	1940	1	56.0	2161	38.6	55.3	0.99	0.600	10.7	1.040	18.6

** Unpublished data.

On the basis of 0.68 gm. of calcium per day per 70-kg. of body weight, the day's need for this element for Subject O was determined to be approximately 0.65 gm. and that for Subject B, 0.54 gm. The intake of 0.87 gm. for Subject O (Table 7) was 33 per cent higher than her calculated standard, while Subject B's intake of 0.60 gm. was only 11 per cent higher. The fact that the balances approached equilibrium, even though the calcium intakes were higher than those commonly recommended for adults, suggests that the present standard for adults is probably too low for young women of this age.

As in the case of protein, the phosphorus balances for both subjects were positive (Table 7), Subject O retaining considerably more on her higher intake than Subject B. The amounts of phosphorus suggested as desirable for these subjects calculated from Sherman's standard of 1.32 gm. per 70-kg. per day were 1.27 gm. for Subject O and 1.06 gm. for Subject B. Subject O's actual daily intake on her freely-chosen diet was 1.67 gm., considerably more than the amount recommended. Subject B used slightly less than her calculated standard, her intake being 1.04 gm. per day.

It would be interesting to know if a larger intake of

nitrogen, calcium, and phosphorus by these subjects would have resulted in greater retention. In that case, it would appear that more of these nutrients should be included in the daily diets of young college women.

CONCLUSIONS

The results of this study indicate that these young women, eating a freely-chosen diet, selected foods in kind and quantity that usually met and often exceeded the Sherman standard for energy, protein, calcium, and phosphorus.

As all but one of the balances were positive, these subjects appeared to be storing nitrogen, calcium, and phosphorus which suggests that growth may not be complete in 17-year old college women. The findings concerning calcium retention suggest that the adult standards may be too low for young women of this age. In both cases, the amounts ingested were considerably above Sherman's standard, yet one subject was only slightly positive while the other was in negative balance.

ACKNOWLEDGMENT

Indebtedness is acknowledged to Dr. Martha Pittman, Head of the Department of Food Economics and Nutrition, for her assistance, interest, and guidance during the collection of data and the preparation of this manuscript, to the two young women who served as subjects for this study, and to T. Doryland for technical assistance in the laboratory.

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