THE PHOSPHORUS INTAKES OF FOUR YOUNG WOMEN OVER A PERIOD OF EIGHT WEEKS

by

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INTRODUCTION

Phosphorus is one of the most abundant minerals in the human body, ranking second only to calcium. According to Chaney and Ahlborn (1939) phosphorus constitutes one per cent of the weight of the human body, which amounts to one and one-fourth pounds for a college girl weighing 125 pounds. Sherman (1937) states that about 70 per cent of the phosphorus content of the body is found in the bones and teeth. Phosphorus, however, is an essential constituent of all living cells. Sherman (1937) quotes "if the biographies of the elements could be written, that of phosphorus would be most interesting."

Bodansky (1934) ably sums up the importance of phosphorus to the body in the following paragraph: "Phosphates are utilized in maintaining the acid-base balance of the blood and in the synthesis of such important cell constituents as the phospholipids and nucleoproteins. The presence in muscle and other tissues of phosphoric acid in combination as creatine phosphate, adenylic acid, adenylic acid pyrophosphate (or triphosphate), hexosephosphate, etc., suggests the manifold importance of phosphorus in nutrition."

Although the importance of an abundance of phosphorus in the diets of college women is recognized, no definite standard for phosphorus intake has been derived for this group. Additional studies of phosphorus intakes of college women seem necessary in order that a definite standard may eventually be derived. This particular study is part of a regional project, the purpose of which is to determine the nutritional status of college women.

Phosphorus intakes may be determined in different ways. Some of these are: group studies with weighed inventories of food and subsequent calculation of average phosphorus intake, determination of individual phosphorus intake from output by analysis of excreta, individual weighed dietary studies with phosphorus content calculated from food composition tables, and individual weighed dietary studies involving direct analysis for phosphorus of an aliquot of the diet.

A group study gives average rather than individual intakes; however, this type has the advantage of making possible the study of dietary habits and intakes of large groups of persons. Analysis of excreta does not give exact information on phosphorus intake, although it is indicative to a

degree. The individual dietary study with phosphorus content calculated gives results based on average food values which may not be typical of the food eaten, as foods vary in composition. The individual weighed dietary analyzed for phosphorus content seems to give most accurate information on exact intake. The fact that this type of study has not been used more extensively is probably due to the long and tedious procedure involved, making impossible the analysis of more than a limited number of diets.

REVIEW OF LITERATURE

Borthwick (1917) computed the nutritive value of the food served over a period of eight days in a residence hall for women at Montana State College. The average intake of phosphorus in the form of phosphorus pentoxide was 2.335 gm. per capita per day, which is equivalent to 1.28 gm. of phosphorus.

Sherman, Gillett, et al.(1918) conducted one of the few early experiments on phosphorus intakes of women. The subjects were two healthy young graduate students. Phosphorus intake and output for each subject were determined quantitatively for "ten successive periods of three days each." As a result of these experiments Sherman concluded that the

minimum requirement for the woman of 50-52 kg. was 0.64 gm. phosphorus daily, and at least 0.60 gm. was necessary for the woman of 57 kg. of body weight. Calculated on the basis of 70 kg. of body weight, the requirement of these subjects was 0.90 and 0.74 gm. per day, respectively.

In experiments conducted on two other young women, Sherman, Wheeler, et al. (1918) found a minimum output of 0.71 gm. phosphorus per day for one subject, weight 60 kg., and 0.69 gm. for the second subject weighing 54 kg. Minimum phosphorus requirements per 70 kg. of body weight per day, computed on the basis of these results, were 0.83 and 0.89 gm., respectively.

Using results of 95 phosphorus balance experiments, some of them recorded in literature and others obtained from unpublished experiments, Sherman (1920) found the phosphorus requirement varied from 0.60 to 1.20 gm. per day for a person weighing 70 kg. The mean was 0.87 gm. for the 34 men subjects and 0.89 gm. for the 61 women while for the entire group, it was 0.88 gm. per day per capita. To this requirement of 0.88 gm., Sherman later added 50 per cent as a "margin of safety" to obtain the standard of 1.32 gm. phosphorus per 70 kg. of body weight which is largely used today. As there was no appreciable difference in the requirement of

men and women, Sherman recommended the same standard for both.

According to Sherman (1920) a study of the diets of 224 families or other groups representative of the population of various sections of the United States showed that all but eight families or groups met the requirement of 0.88 gm. phosphorus per capita per day. The diet of six of these eight would have met the requirement if the caloric intake had been increased to 3,000 Calories per day. The two remaining cases represented southern sections of the United States where patent flour, degerminated corn meal, and sugars and fats constituted the major portion of the food supply.

Kramer and Grundmeier (1926) made a dietary survey of 60 organizations at Kansas State College of Agriculture and Applied Science. The organizations included sororities, fraternities, and boarding houses "supplying meals to fixed groups of students" without the services of a dietitian. Only 20 organizations, "10 sororities, 7 fraternities, and 3 boarding houses for men, feeding 465 students in all," kept adequate records for a period of one month. When phosphorus intakes of these 20 groups were calculated, only 6 groups of men appeared to have daily intakes sufficient to equal the

standard of 1.32 gm. "per man per day." On the basis of 3,000 Calories per day, four groups of men and two of women appeared to have an adequate supply. The investigators concluded that the phosphorus intake was inadequate for more than half of the groups.

Grace (1929), using the inventory method, studied the diets of nine sororities, two home management houses, and one dormitory, at Oregon State College for a period of one week. Calculations, based upon the data collected, "were made and expressed in shares according to Rose." Grace found that the phosphorus furnished by the diets studied "was equal to or above the standard allowance." The milk intake equaled one pint per person per day in only six of the 12 houses studied.

In a summary of the results of nine investigations on nutritive value of food furnished to college students, Hawley (1929) found that the average per capita intake of phosphorus was 1.57 gm. per day or 119 per cent of the standard set by Sherman.

Trump (1930) made a study of the diets of 48 college girls in two sororities at Kansas State College of Agriculture and Applied Science. These organizations were under the direct supervision of a graduate assistant in the

Department of Institutional Economics of the college, who planned the meals, purchased the food, kept records of all foods, and supervised the preparation to a limited extent. The average per capita phosphorus intake for one of the groups was 1.19 gm. per day and 1.46 gm. for the second group; or, calculated on the basis of 3,000 Calories, the groups had mean per capita intakes of 1.53 and 1.60 gm. phosphorus, respectively.

Research conducted on 18 normal college women at Oklahoma Agricultural and Mechanical College by Coons and Schiefelbusch (1932) showed that "the phosphorus intake was low, nearly one-third of the group receiving less than one gram daily." All of the subjects were eating freely chosen diets. Ten subjects were studied for a period of four days, not consecutive; and eight others were studied for seven consecutive days. All foods were weighed and sampled as eaten, the samples representing one-tenth of the total food intake. The dietaries showed that the subjects seldom chose meat and eggs, and only 5 of the 18 included milk in their diets.

In the same year Ryder (1932) made a survey of the nutritive value of food served to a group of college students living in a residence hall at Kansas State College of Agriculture and Applied Science. The group observed consisted

of 137 persons; 125 of them were students of which 121 were women and 4 were men. The duration of the study was two weeks. Ryder used the inventory method, with waste analyzed, and the Hawley Short Method of making calculations. The average phosphorus intake was calculated as 1.197 gm. per capita per day, or 1.971 gm. on the basis of 3,000 Calories. The phosphorus intake was 0.086 gm. above the Sherman standard, the per capita requirement on the basis of 58.2 kg., the mean weight of the subjects, being 1.111 gm.

The dietary practices of ten student organizations consisting of six fraternities and four sororities at Kansas State College of Agriculture and Applied Science were investigated by Shirley (1932) in another study of the weighed inventory type. The mean daily intake of phosphorus per 70 kg. of body weight was 1.59 gm., or 1.40 gm. per 3,000 Calories. Both figures were above the Sherman standard of 1.32 gm. Two sorority groups had per capita intakes of 1.26 and 1.27 gm., respectively. Although these intakes were below the standard of 1.32 gm., they were sufficiently high considering the fact that the mean weights of the groups were less than 70 kg. The mean per capita intake for the four sororities was 1.38 gm. The diets of the groups seemed to be above the standard in phosphorus, but actual intakes

were somewhat lower because no reduction was made for edible waste.

Conard (1934), in a survey of the nutritive value and cost of food served in a sorority at Kansas State College of Agriculture and Applied Science, studied a group of 37, including 31 women students, for a period of two weeks. This study differed from that conducted by Shirley two years previously, in that all edible waste was collected and analyzed, and the amounts deducted from the results. The mean intake was 0.92 gm. phosphorus per capita per day. Based on the Sherman standard of 1.32 gm. per 70 kg., the phosphorus standard for a 55.7 kg. woman, the mean weight of the group, was 1.05 gm. per person per day.

The same year Goddard (1934) made a dietary study of 89 women living in a dormitory at the University of California. The study covered two 8-day periods. "Calculations were made according to the item-by-item method recommended by Rose," and deductions were made for food waste. The estimated phosphorus standard for the group, based on the mean of the requirements of six representative women, was 1.0 gm. per person per day. The daily per capita intake was 1.34 gm. for the first period and 1.15 gm. for the second period.

Jackson (1934) determined phosphorus intakes of a group

of college women in a sorority at Kansas State College of Agriculture and Applied Science. The group consisted of 27 persons, of which 22 were students. The inventory method, with corrections made for food waste, was used for this study which covered a period of two weeks. The daily per capita intake of phosphorus was calculated as 0.97 gm., as compared with a standard of 1.00 gm. based on the mean body weight. The mean intake per 3,000 Calories per day was 1.25 gm. The intakes were practically adequate, being only 0.03 and 0.07 gm. below the respective standards.

The same year 25 healthy women students at Kansas State College of Agriculture and Applied Science served as subjects for phosphorus studies by Kramer et al. (1934). The subjects followed their usual eating habits and kept complete records of foods eaten. The mean weight of each subject was determined and that weight used in making calculations. The mean phosphorus intake, determined by analysis of excreta, for a four-day period in the fall was 1.39 gm. per 70 kg. and 1.40 gm. for a similar period in the winter. However, 44 per cent of the intakes in the fall period and 28 per cent in the winter were below the Sherman standard of 1.32 gm. phosphorus per 70 kg. The per capita intakes of 16 per cent of the subjects in the fall and 8 per cent in the winter

were even below the Sherman requirement of 0.88 gm. phosphorus daily and 72 per cent were below the standard of 1.32 gm. for both periods. The mean intakes were above the Sherman standard, but some individual ones were inadequate.

The eating habits of students patronizing the cafeteria at North Dakota Agricultural College were observed by Latzke (1934) for a ten-day period in the winter and another in the spring. Students had no knowledge of the study so choice of food was not affected. A total of 1,665 trays were observed, including 880 trays of college women. The mean phosphorus intake for the women whose trays were observed was calculated as 0.922 gm. for the winter period and 0.974 gm. for the spring period. The mean for both periods was 0.940 gm. This intake was 28.7 per cent below standard. Latzke concluded that the low intake was due to insufficient use of milk, meat, and meat substitutes in the daily dietary.

A year later Mitchell (1935) reported phosphorus intakes of two classes of college students in home economics. The students weighed their food for one week and calculated the nutritive value from "standard food tables." The phosphorus intakes of one group of 23 students ranged from 0.6 to 1.7 gm., with a mean of 0.98 gm. Eighteen of the subjects had adequate intakes; five were below the Sherman

standard. In the second class of 18 students, the range of phosphorus intakes was from 0.32 to 1.46 gm., with a mean of 0.92 gm. Eleven of this group had adequate intakes and seven were low.

Wheeler and Mallay (1935) found a mean phosphorus intake of 1.32 gm. per person per day or 1.65 gm. per 3,000 Calories, in a cooperative housekeeping group at the Institute of Euthenics, Vassar College. The group consisted of 28 undergraduate women, not students of home economics.

The phosphorus needs of a cooperative group of 126 college women living in a residence hall at Kansas State College of Agriculture and Applied Science were approximately met according to the results of a 14-day inventory study conducted by Schermerhorn (1936). The mean phosphorus intake was 1.13 gm. per subject per day, or 1.62 gm. per 3,000 Calories. The phosphorus standard for 60.5 kg., the mean weight of the group, was 1.14 gm.

Atkinson (1937) made a 14-day study during which an accurate record was kept of all foods consumed by 55 men and 46 women college students taking their meals in the dining room located in the women's dormitory of a denominational college in McPherson, Kansas. The mean daily phosphorus intake was 1.71 gm. per capita, or 1.86 gm. per 3,000 Calories.

The standard based on the mean weight of 61.4 kg. was 1.16 gm. The high phosphorus intake was due to the generous use of milk and meat in the diet.

Analyses of excreta were used by Kramer and Gillum (1938) to determine approximate phosphorus intakes of 23 healthy college women at Kansas State College of Agriculture and Applied Science. The mean intake for the first part of the experiment, while the subjects followed their usual eating habits, was 1.26 gm. phosphorus per 70 kg. of body weight. Two subjects had intakes below the Sherman requirement of 0.88 gm., and 14 had intakes below the Sherman standard of 1.32 gm. During the second part of the study, the subjects were asked to include no milk or cheese in their diets. The mean phosphorus intake per 70 kg. dropped to 0.94 gm. per day, with the intakes of 22 subjects below the Sherman standard and 9 of them below the Sherman requirement. In the third period seven subjects participated, omitting all high protein foods of animal origin. The mean intake of phosphorus was 0.77 gm. per 70 kg., and all but one subject had intakes below the Sherman requirement.

Chen (1938) determined the phosphorus intakes of two women students at Kansas State College of Agriculture and Applied Science by means of an individual weighed dietary

study while the subjects ate their normal freely chosen diet. The mean intake of one subject was 0.996 gm., or 1.737 gm. per 3,000 Calories, and 1.452 gm. per 70 kg. The second subject consumed 1.06 gm. phosphorus per day, 1.596 gm. per 3,000 Calories, or 1.487 gm. per 70 kg. per day. The phosphorus intakes of both subjects were above the Sherman standard per 3,000 Calories and per 70 kg. of body weight.

Out of 500 records of the weekly food consumption of students in beginning courses in nutrition at Utah State Agricultural College, Morris and Bowers (1939) chose 100 of the most carefully compiled lists. The nutritive value of the diets was calculated and compared with accepted standards for good nutrition. The mean phosphorus intake for the group of 100 students was 1.103 ($\pm$ 0.053) gm., as compared with the Sherman standard of 1.32 gm. The mean intake of 15 students living in the dormitory was 1.20 ($\pm$ 0.073) gm. and for 34 living in bachelor quarters, 1.12 ($\pm$ 0.042) gm. For 32 students boarding and for 19 living at home, the mean intakes were 1.07 and 1.04 ($\pm$ 0.046) gm. respectively. The students living in the dormitory had the highest phosphorus intakes, and those living at home the lowest. The investigators concluded that the diets of the group as a whole were deficient in phosphorus compared with the Sherman standard of 1.32 gm.

PROCEDURE

An 8-week study was made on the individual phosphorus intakes of four young college women eating their customary freely chosen diets. The subjects were determined to be normal and healthy in all respects by means of physical examinations made by the student health department of the college. Three of the students were majoring in home economics and the fourth had a minor in that field. This background gave them a fair understanding of the nature of the study and a desirable interest in it.

The young women were moderately active, walking several blocks to and from the campus two or more times daily, and performing the duties required for light housekeeping. The subjects took turns in planning and preparing meals for the group. They had no outside help or direction; however, their meal planning and preparation undoubtedly were influenced by knowledge obtained from their study of foods and nutrition in the classroom.

During the 8-week period all drinking water and all food eaten by each subject were weighed by a member of the Department of Food Economics and Nutrition of Kansas State

College of Agriculture and Applied Science. Portions equivalent to one-tenth of the amount of the food eaten by each subject were retained as samples for future analysis. All foods served but not eaten were also weighed and these amounts deducted from the totals before calculating and weighing the samples. As there were no restrictions on the diets, the subjects ate away from home whenever they wished, but they either weighed and sampled the food thus eaten or obtained a portion as nearly identical as possible which was weighed and sampled; however, with few exceptions, all the food was prepared and eaten at home.

The daily food aliquot for each subject, preserved by the addition of one drop of formaldehyde, was transferred to a large evaporating dish each morning making a composite sample for each week; this was dried in a gas oven held at approximately 60° C., a temperature low enough to prevent charring. Drying was continuous from the time the first daily aliquot was placed in the evaporating dish until the weight of the food composite was approximately constant, i.e., it varied not more than two grams on successive weighings 24 hours apart.

At the conclusion of the drying process, the food was ground in a food chopper after which it was sifted through a

Table 1. Personal Data.

Data	Subject			
	Le	Lu	M	R
Age in years to nearest birthday	20	22	19	20
Classification in college	Sophomore	Junior	Special	Sophomore
Major field of study	Home Economics	Industrial Journalism	Home Economics	Home Economics
Minor field of study		Home Economics		
Height in centimeters	165.2	167.8	159.7	167.4
Average weight in pounds	123	127	115	141
Average weight in kilograms	56.04	57.74	52.40	63.93
Activity	Moderate	Moderate	Moderate	Moderate
Chief form of exercise	Walking and gymnasium	Walking	Walking	Walking
Average hours of sleep per day*	6.75	7.8	8.7	7.7
Smoking	None	None	None	None
Health	Good	Good	Good	Good
Type of build	Average	Average	Average	Average
Basal metabolic rate compared with DuBois standard				
Range of 4 tests	-6.9 -4.6	-7.4 -8.9	-6.7 -6.7	-12.3 -12.3
Mean	-5.8	-8.2	-6.7	-12.3

* Sleep was recorded for only the last four of the eight weeks.

Day	Breakfast	Lunch	Dinner	Between meals	
				Food	Subject eating
Sun.	Grapefruit	Cheese sandwiches	Chicken	Apples	M
	Toast	Cookies	Mashed potatoes	Cookies	M
	Butter	Apples	Cranberry salad		
	Cocoa	Milk	Buns		
			Butter		
			Honey		
			Cake		
Mon.	Grapefruit	Beef sandwiches	Meat pie	Candy bar	M
	Toast	String beans	Mashed potatoes		
	Butter	Fruit salad	Creamed peas	Cookie	M
	Cocoa	Chocolate cake	Lettuce salad	Cookie	R
		Milk	Biscuits		
			Butter		
			Honey		
			Chocolate pudding		
			Cookies		
Tues.	Grapefruit	Scrambled eggs with bacon	Scalloped potatoes	Apple	M
	Toast	Tomatoes	Buttered corn		
	Butter	Fruit salad	Stuffed celery		
	Cocoa	Bread	Bread		
		Butter	Butter		
		Cake	Pineapple upside-down cake		
		Milk			
Wed.	Pineapple and grapefruit juice	Lunch ham sandwiches	Bacon and eggs	Apple	M
		Celery	Scalloped corn		
		Apples	Lettuce salad		
	Grape-nut flakes	Cookies	Bread		
		Milk	Butter		
	Milk		Bananas with chocolate sauce		
	Rolls		Cookies		
	Cocoa		Milk		
Thurs.	Dried apricots	Cheese sandwiches	Ground beef cakes	Apple	Le
			Gravy		
	Shredded wheat biscuits	Tomatoes	Browned potatoes		
		Gelatin salad	Buttered beets		
		Cookies	Relish		
	Milk	Milk	Bread		
			Butter		
			Apricot sauce		
			Doughnuts		
Fri.	Oranges	Potato salad	Pork tenderloin	Apple-butter sandwich	Le
	Fried eggs	Carrots	Gravy		
	Toast	Celery	Cottage cheese salad		
	Butter	Toast			
		Butter	Bread	Apple	Le
		Bananas	Butter	Apples	M
		Cookies	Apple butter	Apple-butter sandwich	M
		Milk	Ice cream		
Sat.	Oranges	Cheese sandwiches	Beef	Candy	Le
	Shredded wheat biscuits	Pickles	Gravy	Candy	R
		Apricot sauce	New potatoes		
		Doughnuts	Cabbage slaw		
	Milk	Milk	Bread		
	Toast		Butter		
	Butter		Cranberries		
	Milk		Cookies		

Day	Breakfast	Lunch	Dinner	Between meals	
				Food	Subject eating
Sun.	Oranges	Cheese sandwiches	Beef steak	Candy	Le
	Toast	Bananas	New potatoes and peas	Candy	M
	Butter	Doughnuts	Salad		
	Cocoa	Cocoa	Relish		
			Bread		
			Butter		
			Cookies		
			Milk		
Mon.	Cranberries	Tomato soup	Beef steak and gravy	Candy	Le
	Shredded wheat biscuit	Crackers		Candy	M
		Salad	Mashed potatoes	Apple	M
		Cookies	Creamed carrots	Candy	R
	Milk		Vegetable salad		
	Toast		Pickles		
	Butter		Rolls		
	Cocoa		Butter		
			Cookies		
Tues.	Oranges	Breaded tomatoes	Tomato juice	Candy	Le
	Toast	Cookies	Chicken and dressing	Candy	Lu
	Butter	Apples		Candy	M
	Apple butter	Milk	Potatoes	Candy	R
			Salad		
			Rolls		
			Butter		
			Carrot pudding		
			Lemon sauce		
Wed.	Orange juice	Creamed dried beef on toast	Tomato juice		
	Rolled oats		Scrambled eggs		
	Milk	Cabbage and green pepper salad	Browned potatoes		
	Toast		Carrots		
	Butter		Bread		
		Cherries	Butter		
		Cookies	Apple butter		
			Cranberries		
			Cookies		
Thurs.	Orange and pineapple juice	Creamed eggs on toast	Sausage		
			Gravy		
		Carrot and pineapple salad	Green beans		
	Toast		Cabbage slaw		
	Butter	Cherries	Bread		
	Cocoa	Cookies	Butter		
			Apple roll		
			Cream		
Fri.	Grapefruit and pineapple juice	Tomato juice	Salmon	Orange	Le
		Celery and carrots	String beans	Cookie	Le
			Salad	Orange	M
		Bread	Bread		
	Rolled oats	Butter	Butter		
	Milk	Rice with raisins	Baked apples		
	Toast	Milk	Cream		
	Butter	Pineapple pie			
	Cocoa				
Sat.	Grapefruit	Weiners	Weiners	Cream cheese sandwich	M
	Toast	Sauerkraut	Potatoes		
	Butter	Celery	Creamed corn		
	Cocoa	Carrots	Bread		
		Bread	Butter		
		Butter	Apricots		
		Pineapple roll	Ginger cake		
		Milk	Milk		

Table 2. Continued. Week 3.

Day	Breakfast	Lunch	Dinner	Between meals	
				Food	Subject eating
Sun.	Grapefruit	Canned peaches	Pork tenderloin		
	Toast	Cookies	Potatoes		
	Butter	Apples	Corn		
		Milk	Celery		
			Bread		
			Butter		
			Canned apricots		
			Cookies		
Mon.	Grapefruit	Cheese sand-	Vegetable soup	Cream	Lu
	Rolled oats	wiches	Crackers	cheese	
	Milk	String beans	Apple butter	sand-	
	Toast	Bananas	Peaches	wich	
	Butter	Cookies	Cookies	Apples	M
	Milk	Milk	Milk	Cookie	M
Tues.	None	Creamed potatoes	Vegetable soup	Apple	Le
		Buttered carrots	Crackers	Cookie	Le
		Biscuits	Fruit gelatin	Apple	M
		Butter	salad	Candy	M
		Apple butter		bar	
		Rice pudding			
		Top milk			
Wed.	Grapefruit	Beef sandwiches	Macaroni and	Apples	M
	Rolled oats	Creamed potatoes	cheese	Sand-	M
	Milk	Tomatoes	Carrot and raisin	wich	
	Toast	Fruit gelatin	salad	Sand-	R
	Butter	salad	Bread	wich	
	Milk	Ginger cookies	Butter		
			Ice cream		
			Graham crackers		
Thurs.	Grapefruit	Sweet potatoes	Beef steak	Apple	Le
	Rolled oats	Salad	Minced vegetables	Cookies	Le
	Milk	Bread	Stuffed celery	Apple	M
	Toast	Butter	Bread	Cookie	M
	Butter	Apple sauce	Butter	Apple	R
	Cocoa	Doughnuts	Pudding	Cookie	R
		Milk	Graham crackers		
Fri.	Orange and	Creamed lima beans	Hamburgers	Ice	Le
	pineapple	Lettuce salad	Buttered beans	cream	
	juice	Sweet rolls	Fruit salad	Cake	Le
	Rolled oats	Stewed apples	Pickles	Rice	Lu
	Milk	Milk	Buns	Blanc	Lu
	Toast		Graham cracker	mange	
	Butter		roll	Apple	M
	Milk			Apple	R
				Roll	R
Sat.	Apple sauce	Hamburgers	Salmon salad		
	with pine-	Gravy	Potato chips		
	apple	Apple salad	Pickles		
	Cocoa	Bread	Bread		
		Butter	Butter		
		Apricots	Apricots		
		Graham crackers	Apples		

Table 2. Continued. Week 4.

Day	Breakfast	Lunch	Dinner	Between meals	
				Food	Subject eating
Sun.	None	Cherries Graham crackers with chocolate icing Milk	Roast beef Gravy Mashed potatoes Pineapple salad Pickles Bread Butter Cherries Graham crackers with chocolate icing Milk	Graham crackers with chocolate icing	R
Mon.	Orange juice Biscuits Butter Apple butter	Tomatoes Carrots Bread Butter Apples Doughnuts Milk	Spaghetti and ground beef Baked potatoes Lettuce salad Bread Butter Stewed prunes Cookies	Potato chips Dough-nut Apple Cookie Dough-nut Cookie	Le Lu M M R R
Tues.	Stewed prunes Beef gravy on toast Milk	Beans Pineapple salad Bread Butter Graham crackers with chocolate icing	Beef steak Beets Pineapple-banana salad Bread Butter Ginger cookies	Graham crackers with chocolate icing Cookie Graham crackers with chocolate icing	Le M R
Wed.	Oranges Rolled oats Milk Toast Butter Milk	Creamed lima beans Cabbage and carrot salad Bread Butter Cookies Milk	American cheese Baked potatoes Carrots Bread Butter Apple pie	Apple Pastry	M R
Thurs.	Prunes and apples Rolled oats Milk Toast Butter Cinnamon pastry	Peanut butter sandwiches Carrots Harvard beets Pickles Bananas	Macaroni and cheese Bacon Tomatoes Bread Butter Fruit shortcake		
Fri.	Grapefruit Rolled oats Milk Toast Butter Milk	Creamed dried beef on toast Carrot and cabbage salad	Macaroni and cheese Spinach with bacon sauce Mashed potatoes Bread Butter Fruit shortcake	Candy Candy Candy Sandwich	Le M R R
Sat.	Grapefruit *Bran flakes* Milk Toast Milk	Toasted cheese sandwiches Lettuce salad Doughnuts Milk	Oyster stew *Crackers* Celery Bread Butter Apple butter Apricots Coconut cookies	Candy *Candy* Candy	Le *M* R

Table 2. Continued. Week 5.

Day	Breakfast	Lunch	Dinner	Between meals	
				Food	Subject eating
Sun.	Grapefruit	Meat sandwiches	Meat loaf	Pastry	M
	Toast	Pickles	Mashed potatoes	Candy	M
	Butter	Cookies	Spinach		
	Cocoa	Milk	Carrot strips		
			Bread		
			Butter		
			Apricot pie		
Mon.	Grapefruit	Peanut butter	Hamburger	Cookies	Le
	Canned plums	sandwiches	Gravy	Apple	M
	Bran	Tomatoes	Baked potatoes		
	Milk	Doughnuts	Carrots		
	Toast	Cocoa with marsh-	Celery		
	Butter	mallow	Bread		
			Butter		
			Baked apples		
			Vanilla ice cream		
			White angel cake		
Tues.	Tomato juice	Dried beef rarebit	Creamed potatoes	Candy	M
	Rolled oats	Toast	Asparagus	bar	
	with	Cranberry salad	Cabbage and green	Ice	R
	raisins	Cake	pepper salad	cream	
	Toast		Bread	Cookies	R
	Butter		Butter	Dough-	R
	Milk		Peaches	nut	
			Angel food cake		
Wed.	Tomato juice	Toasted cheese	Meat stew	Apple	Le
	Grape-nut	sandwich	Crackers	Apple	M
	flakes	Tomatoes	Canned peaches	Banana	R
	Milk	Apples	Doughnuts		
	Toast	Doughnuts	Milk		
	Butter	Cocoa			
	Milk				
Thurs.	Oranges	Baked beans	Hamburger	Cus-	M
	Rolled oats	Creamed asparagus	Gravy	tard	
	Milk	Toast	Scalloped potatoes	Dough-	M
	Toast	Butter	Buttered peas	nuts	
	Butter	Apples	Apple salad		
	Milk	Milk	Bread		
			Butter		
Fri.	Oranges	Fried eggs	Meat stew	Cookies	Le
	Grape-nuts	Pickles	Scrambled eggs	Apple	Le
	Milk	Bread	Lettuce salad	Cookie	R
	Toast	Butter	Bread	Cake	R
	Butter	Cranberry sauce	Butter		
		Chocolate cake	Cookies		
		Milk			
Sat.	Oranges	Peanut butter	Fried salmon	Omelet	M
	Fried eggs	sandwiches	Mashed potatoes	Apple	M
	Toast	Tomatoes	Harvard beets	Apple	R
	Butter	Stewed prunes	Apple and banana		
	Milk	Cookies	salad		
		Milk	Bread		
			Butter		
			Ice cream		
			Chocolate cake		

Day	Breakfast	Lunch	Dinner	Between meals	
				Food	Subject eating
Sun.	Stewed prunes	Ham sandwiches	Swiss steak		
	Cooked cereal	Pickles	Scalloped potatoes		
	Milk	Candy bars			
	Toast		Wilted spinach		
	Butter		Vegetable salad		
			Bread		
			Butter		
			Baked custard		
			Apples		
Mon.	Oranges	Bacon sandwiches	Browned potatoes	Cookies	Le
	Cinnamon toast	Gelatin salad	Creamed celery	Cookie	M
	Milk	Celery	Cabbage salad		
		Bananas	Bread		
		Cookies	Butter		
		Milk	Apple sauce		
			Cookies		
Tues.	Sliced oranges	Soup	Soup	Apple	Lu
	Poached eggs	Crackers	Crackers	Apples	M
	Toast	Banana and chocolate pudding	Celery	Apple	R
	Butter		Radishes	Cookies	R
			Strawberry short cake		
			Milk		
Wed.	Canned plums	Cheese sandwiches	Hamburger and spaghetti	Cookies	Le
	Toast	Stewed tomatoes		Cake	Le
	Butter	Lettuce salad	Mashed potatoes	Apples	Le
	Milk	Butterscotch pudding	Gravy	Apple	Lu
			Celery	Apple	R
			Radishes		
			Bread		
			Butter		
			Plums		
			Cookies		
Thurs.	Orange juice	Creamed eggs on toast	Pork chops	Cookies	Le
	Grape-nut flakes	Harvard beets	Gravy	Cake	Le
	Toast	Tomato salad	Scalloped corn	Apple	M
	Butter	Milk	Bread	Cookies	M
	Cocoa		Butter	Cookies	R
			Apricots		
Fri.	Sliced oranges	Bacon sandwiches	Fillet of haddock	Orange juice and ginger ale	All
	Soft cooked eggs	Peas	Potatoes		
	Toast	Sliced peaches	Cabbage salad		
	Butter	Cookies	Muffins		
		Milk	Butter	Ice cream	All
			Fruit cup		
				Orange	M
Sat.	Oranges	Boiled ham	Flank steak and dressing		
	Grape-nut flakes	Celery	Scalloped potatoes		
	Milk	Carrots			
		Bread	Celery		
		Butter	Pineapple and cheese salad		
		Apples			
		Cake	Buns		
		Milk	Butter		
			Chocolate cake		

Table 2. Continued. Week 7.

Day	Breakfast	Lunch	Dinner	Between meals	
				Food	Subject eating
Sun.	Sliced oranges	Potato salad	Boiled ham	Apple	M
	Cooked cereal	Bread	Tomatoes	Cookies	M
	Milk	Butter	Salad		
	Toast	Ice cream	Buns		
	Butter	Cookies	Butter		
			Apricots		
			Cake		
			Milk		
Mon.	Soft-cooked eggs	Sandwiches	Lunch ham	Orange drink	Le
	Toast	Celery	Hard-cooked eggs	Orange drink	M
	Butter	Apple sauce	Beans and catsup	Orange drink	R
		Cake	Vegetable salad		
		Cookies	Bread		
		Milk	Butter		
			Fruit cup		
Tues.	Sliced oranges	Macaroni and tomatoes	Baked beans		
	Poached eggs	Salad	Cheese		
	Toast	Bread	Spinach		
	Butter	Butter	Bread		
		Strawberry short-cake	Butter		
		Milk	Prune cream		
Wed.	Sliced oranges	Creamed cauliflower	Meat and vegetable stew		
	Rice	Gelatin salad	Lettuce salad		
	Milk	Bread	Bread		
	Toast	Butter	Butter		
	Butter	Doughnuts	Rhubarb pie		
		Milk			
Thurs.	Sliced oranges	Salmon salad	Scalloped potatoes	Apple	Le
	Grape-nut flakes	Tomatoes	Buttered peas	Apple	M
	Milk	Bread	Bread	Orange	M
	Toast	Butter	Butter		
	Butter	Cherries	Fruit cup		
		Doughnuts			
		Milk			
Fri.	Oranges	Potato salad	Hamburger sandwiches	Doughnut	M
	Scrambled eggs	Tomatoes	Creamed corn		
	Toast	Bread	Doughnuts		
	Butter	Butter	Peaches		
		Chocolate pudding	Milk		
		Doughnuts			
Sat.	Sliced oranges	Peanut butter sandwiches	Weiners	Cake	M
	Shredded wheat biscuit	Tomatoes	Potato chips		
	Milk	Carrot strips	Celery		
	Toast	Apples	Bread		
	Butter	Milk	Butter		
			Mince pie		
			Milk		

Table 2. Continued. Week 8.

Day	Breakfast	Lunch	Dinner	Between meals	
				Food	Subject eating
Sun.	Oranges	None	Meat loaf	Cake	Le
	Eggs		Baked beans	Nuts	Le
	Toast		Potato salad	Cookies	Le
	Butter		Bread	Dried beef	Le
	Milk		Butter		
			Fruit salad	Cake	M
				Cake	R
Mon.	Oranges	Baked beans	Creamed dried beef on toast	Cake	Le
	Toast	String beans		Potato chips	Le
	Butter	Potato salad	Spaghetti with tomatoes		
	Cocoa	Bread	Cabbage slaw		
		Butter	Fruit salad		
		Chocolate cake	Cookies		
		Milk			
Tues.	Oranges	Tomatoes and macaroni	Salmon loaf	Candy bar	Le
	Rolled oats		Mashed potatoes		
	Milk	Creamed corn	Peas	Sherbet	M
	Cocoa	Cabbage slaw	Carrot strips	Cake	M
		Bread	Raisin bread		
		Butter	Butter		
		Fruit gelatin	Bananas with milk		
		Chocolate cake			
Wed.	Oranges	Cheese sandwiches	Hamburgers	Banana	Le
	Scrambled eggs		Gravy	Cookie	Le
		Lettuce salad	Mashed potatoes	Candy bar	Le
	Toast	Doughnuts	Creamed carrots		
	Butter	Milk	Bread	Candy	Le
	Milk		Butter	Banana	R
			Chocolate cake	Cookie	R
				Candy bar	R
				Candy	R
Thurs.	Sliced oranges	Bean salad	Salmon		
	Shredded wheat biscuits	Spinach	Creamed peas and carrots		
		Raisin bread	Bread		
		Butter	Butter		
		Oranges	Cake		
	Milk	Doughnuts			
	Toast	Milk			
	Butter				
Fri.	Oranges	Hamburger sandwiches	Tomato juice		
	Scrambled eggs		Carrot salad		
		Tomatoes	Bread		
	Toast	Lettuce salad	Butter		
	Butter	Cinnamon rolls	Rice custard		
	Milk		Milk		
Sat.	Tomato juice	Bean salad	Tomato juice	Cookies	M
	Creamed dried beef on toast	Carrots	Hamburger sandwiches		
		Bread			
		Butter	Radishes		
		Prunes	Strawberry shortcake		
		Cookies			
		Milk	Cream		

20-mesh sieve. Particles too large to pass through the sieve were reduced in a mortar. The finely divided food was stored in glass-stoppered bottles until analyzed.

The dried food mixture was sampled according to accepted methods. A sufficient amount of this well-mixed material was placed in a glass weighing bottle, dried for three hours in an electric oven at 60° C., and cooled in a dessicator. Three and a half-gram samples were then accurately weighed on an analytical balance, this amount of mixed dried food being considered a suitable quantity for phosphorus analysis.

These samples were analyzed gravimetrically by the Neumann method (1903) as modified by Lundell and Hoffman (1923) and by McCandless and Burton (1924). All analyses were made in triplicate to insure reliability of results. Preliminary analyses of known solutions insured accuracy of technique.

DISCUSSION AND RESULTS

The mean weekly phosphorus intake of subject Le was 9.368 gm. which amounted to 1.338 gm. daily (Table 3). This represented a mean of 1.783 gm. of phosphorus per 3,000 Calories or 1.671 gm. per 70 kg. of body weight. These amounts were 35 and 27 per cent, respectively, above

Table 3. Phosphorus Intakes.

Subject	Week	Dried food other than visible fat	Phosphorus per gm. dried food	Total phosphorus intake					
				Per week	Per day	Per 70 kg. per day	Per kg. per day	Per 3000 Calories	Per 100 Calories
		gm.	mg.	gm.	gm.	gm.	mg.	gm.	mg.
Le (56.04 kg.)	1	3297	3.8	12.585	1.798	2.246	32.2	2.151	71.7
	2	3346	2.7	8.951	1.279	1.598	22.8	1.693	56.4
	3	3273	2.6	8.664	1.238	1.546	22.1	1.692	56.4
	4	2892	2.9	8.300	1.186	1.481	21.2	1.753	58.4
	5	3273	3.0	9.757	1.394	1.741	24.9	1.773	59.1
	6	3107	2.7	8.311	1.187	1.483	21.2	1.652	55.1
	7	3074	2.7	8.309	1.187	1.483	21.2	1.645	54.8
	8	3376	3.0	10.064	1.438	1.796	25.7	1.850	61.7
	Mean	3205	2.9	9.368	1.338	1.671	23.4	1.783	59.4
	Standard per day				0.740	1.32	18.9	1.32	44.0

Table 3. Continued.

Subject	Week	Dried food other than visible fat	Phosphorus per gm. dried food	Total phosphorus intake					
				Per week	Per day	Per 70 kg. per day	Per kg. per day	Per 3000 Calories	Per 100 Calories
		gm.	mg.	gm.	gm.	gm.	mg.	gm.	mg.
Lu (57.74 kg.)	1	2728	3.9	10.716	1.531	1.856	26.5	2.148	71.6
	2	2965	3.1	9.251	1.322	1.603	22.9	1.936	64.5
	3	2962	3.1	9.241	1.320	1.600	22.9	2.211	73.7
	4	2853	3.1	8.981	1.283	1.555	22.2	1.755	58.5
	5	3129	3.0	9.328	1.333	1.616	23.1	1.914	63.8
	6	3052	2.8	8.503	1.215	1.473	21.0	1.795	59.8
	7	2932	2.9	8.415	1.202	1.457	20.8	1.616	53.5
	8	2963	3.3	9.742	1.392	1.688	24.1	2.210	73.7
	Mean	2948	3.2	9.272	1.325	1.606	22.9	1.935	64.5
	Standard per day				0.762	1.32	18.9	1.32	44.0

Table 3. Continued.

Subject	Week	Dried food other than visible fat	Phosphorus per gm. dried food	Total phosphorus intake					
				Per week	Per day	Per 70 kg. per day	Per kg. per day	Per 3000 Calories	Per 100 Calories
		gm.	mg.	gm.	gm.	gm.	mg.	gm.	mg.
M (52.40 kg.)	1	3207	3.7	11.795	1.685	2.251	32.2	1.989	66.3
	2	2674	2.2	5.885	0.841	1.123	16.0	1.420	47.3
	3	2918	2.6	7.520	1.074	1.435	20.5	1.532	51.1
	4	2275	3.0	6.718	0.960	1.282	18.3	1.414	47.1
	5	3470	2.8	9.667	1.381	1.845	26.4	1.828	60.9
	6	3042	2.5	7.711	1.102	1.472	21.0	1.707	56.9
	7	2966	2.6	7.684	1.098	1.467	21.0	1.560	52.0
	8	2807	2.9	8.056	1.151	1.538	22.0	1.749	58.3
	Mean	2920	2.8	8.130	1.162	1.552	22.2	1.666	55.5
	Standard per day				0.692	1.32	18.9	1.32	44.0

Table 3. Continued.

Subject	Week	Dried food other than visible fat	Phosphorus per gm. dried food	Total phosphorus intakes					
				Per week	Per day	Per 70 kg. per day	Per kg. per day	Per 3000 Calories	Per 100 Calories
		gm.	mg.	gm.	gm.	gm.	mg.	gm.	mg.
R (63.93 kg.)	1	2994	4.0	11.928	1.704	1.866	26.7	2.217	73.9
	2	2961	2.8	8.332	1.190	1.303	18.6	1.781	59.4
	3	3063	2.9	8.959	1.280	1.402	20.0	1.917	63.9
	4	3050	3.0	9.007	1.287	1.409	20.1	2.184	72.8
	5	3359	2.6	8.797	1.257	1.376	19.7	1.679	56.0
	6	3070	2.5	7.782	1.112	1.218	17.4	1.830	61.0
	7	3195	2.8	8.812	1.259	1.379	19.7	1.750	58.3
	8	3180	3.1	9.922	1.417	1.552	22.2	1.634	54.5
	Mean	3110	3.0	9.192	1.313	1.438	20.5	1.863	62.1
	Standard per day				0.844	1.32	18.9	1.32	44.0

the Sherman standard of 1.32 gm. In proportion to body weight, her per capita consumption was 82 per cent above the usual recommendation.

The phosphorus consumed by subject Lu averaged 9.272 gm. per week, 1.325 gm. daily, 1.935 gm. on the basis of 3,000 Calories, and 1.606 gm. for 70 kg. of body weight (Table 3). These amounts were approximately 74 per cent above the per capita standard, 47 per cent above that for 3,000 Calories, and 30 per cent in excess of the approved amount per 70 kg.

The diet of subject M furnished 8.130 gm. phosphorus per week (Table 3) or 1.162 gm. per day, which was approximately 40 per cent above her calculated need. Her intakes per 3,000 Calories and per 70 kg. of body weight were 1.666 gm. and 1.552 gm., respectively, or about 26 and 19 per cent above the usual amount of 1.32 gm.

The mean weekly intake of phosphorus for subject R was 9.192 gm. (Table 3). Her daily consumption was 1.313 gm., approximately 55 per cent above the amount suggested as desirable. Calculated on the basis of 3,000 Calories, this subject consumed 1.863 gm. phosphorus which exceeded the standard by 40 per cent. Her intake per 70 kg. was 1.438 gm., almost 9 per cent above the ideal of 1.32 gm.

Of the four subjects, Le had the highest per capita phosphorus intake, also the highest per kilogram of body weight (Table 4). Her diet was likewise highest in energy, but it was third in phosphorus per 3,000 Calories.

Subject Lu ranked second in mean weekly and daily phosphorus consumed, first in phosphorus per 3,000 Calories, and second per kilogram of body weight (Table 4). Her diet was lowest in energy.

The total phosphorus intake of subject M was somewhat lower than that of the others (Table 4). It was fourth on the basis of 3,000 Calories, for the caloric value of her diet was rather high. Per kilogram of weight, her consumption of this mineral was next to the lowest.

Subject R, whose diet was second in fuel value, was third in weekly and daily consumption of phosphorus, second per 3,000 Calories, and fourth per kilogram of body weight (Table 4).

An effort was made to determine whether increased caloric value of the diets resulted in a parallel variation in phosphorus content. Fuel and phosphorus values of the diet of Le were identical in rank for six of the eight weeks (Table 5), showing that higher energy value in her case was probably due to an increased intake of all foods in

Table 4. Results of This Study Compared with the Sherman Standard.

Phosphorus					
Unit	Subjects of this study				Sherman standard
	Le	Lu	M	R	
Gm. per capita per day	1.338	1.325	1.162	1.313	1.32
Gm. per 3,000 Calories	1.783	1.935	1.666	1.863	1.32
Gm. per 70 kilograms	1.671	1.606	1.552	1.438	1.32
Mg. per 100 Calories	59.4	64.5	55.5	62.1	44.0
Mg. per kilogram	23.4	22.9	22.2	20.5	18.9

Table 5. Relation of Mean Phosphorus Intakes to Caloric Value of the Diet.

Subject	Week	Calories		Phosphorus		Subject	Week	Calories		Phosphorus	
		Mean/day	Rank	Mean/day	Rank			Mean/day	Rank	Mean/day	Rank
Le	1	2508	1	1.798	1	M	1	2541	1	1.685	1
(56.04 kg.)	2	2266	4	1.279	4	(52.40 kg.)	2	1777	8	0.841	8
	3	2195	5	1.238	5		3	2103	4	1.074	6
	4	2030	8	1.186	8		4	2037	5	0.960	7
	5	2358	2	1.394	3		5	2267	2	1.381	2
	6	2155	7	1.187	6		6	1937	7	1.102	4
	7	2165	6	1.187	7		7	2111	3	1.098	5
	8	2332	3	1.438	2		8	1974	6	1.151	3
	Mean	2251					Mean	2093			
Lu	1	2138	3	1.531	1	R	1	2306	2	1.704	1
(57.74 kg.)	2	2049	5	1.322	4	(63.93 kg.)	2	2005	5	1.190	7
	3	1791	8	1.320	5		3	2003	6	1.280	4
	4	2193	2	1.283	6		4	1768	8	1.287	3
	5	2089	4	1.333	3		5	2246	3	1.257	6
	6	2031	6	1.215	7		6	1823	7	1.112	8
	7	2246	1	1.202	8		7	2158	4	1.259	5
	8	1890	7	1.392	2		8	2601	1	1.417	2
	Mean	2054					Mean	2114			

general which resulted in a corresponding rise in phosphorus.

This relation, however, was not found for energy and for phosphorus consumed by subject Lu, e.g., week 7 was first in energy and eighth in phosphorus, and week 4 ranked second in fuel value and sixth in phosphorus.

In the case of subject M, weeks 1, 2, and 5 ranked first, eighth, and second, respectively, in both caloric value and phosphorus content, but the values were not parallel for the other five weeks (Table 5).

The first week of the study, the diet of subject R was second in energy and first in phosphorus. Values for energy and phosphorus were similarly related in weeks 7 and 8, but the relationship for the other five weeks was even less evident.

Identical ranks for fuel and phosphorus in the diets were found in 9 out of 16 instances for two of the subjects, suggesting that for these two women an increase in calories and phosphorus was often the result of eating more of all foods. For the four subjects, a change in the total energy value of the diet brought about a corresponding variation in phosphorus content only 28 per cent of the time. In other words, most cases of higher energy intake were

apparently due to eating more carbohydrates rather than to an increased consumption of all foods served which would have raised the intake of phosphorus.

The per capita phosphorus intakes of the four subjects in this investigation were higher than those determined by Chen (1938) in a similar study of two college women (Table 10). Three of these subjects consumed more phosphorus per 70 kg. of body weight than either of those observed by Chen. On the basis of 3,000 Calories, three again consumed more of this mineral than one of Chen's subjects, and the consumption of all four was above that of Chen's other subject.

Three of the women in this experiment used more phosphorus per capita than the mean obtained by Coons and Schiefelbusch (1932) in an individual weighed dietary study of 18 subjects, and two consumed more of this mineral per 3,000 Calories (Table 10).

The phosphorus consumption of all four of these subjects was above the mean obtained by Kramer et al. (1934), by Schermerhorn (1936), and by Kramer and Gillum (1938) (Table 10). However, the women in this study consumed less phosphorus per 70 kg. than the mean determined by Ryder (1932).

The per capita phosphorus intakes (Table 10) of subjects Le and Lu were higher than those determined by all the investigators noted other than Trump (1930) for Period II, Shirley (1932), Goddard (1934) for Period I, and Atkinson (1936). Subject R had a per capita intake lower than those mentioned above and also lower than that observed by Wheeler and Mallay (1935). Subject M consumed less phosphorus than the mean obtained in any of the investigations mentioned above and also less than was used by subjects studied by Trump (1930) in Period I, Ryder (1932), and Coons and Schiefelbusch (1932).

Per 3,000 Calories, subjects Lu and R had phosphorus intakes (Table 10) higher than those found in any study reported here with the exception of Ryder's (1932). Subject Le was exceeded only in the experiments conducted by Ryder (1932), Atkinson (1937), and Coons and Schiefelbusch (1932); subject M used less phosphorus per 3,000 Calories than any of the above and also less than one of Chen's subjects.

The per capita phosphorus intake of subject Le was fifth when compared with results obtained from 19 other investigations; it was fourth on the basis of 3,000 Calories in comparison with 15 other studies, and next to the highest compared with intakes per 70 kg. derived from 7 other

experiments. Lu, in comparison with the results of the same investigations, was fifth in per capita consumption, second per 3,000 Calories, and second per 70 kg.; subject M ranked tenth, fifth, and second, respectively; and R was sixth, second, and fourth.

The diets of the four subjects appeared to have met the customary standards for phosphorus in all respects (Table 4). Although per capita intakes of two of the women were below 1.32 gm. which is sometimes used as a standard, both subjects consumed more phosphorus in proportion to their weight than was necessary on the basis of 1.32 gm. per 70 kg. The mean intake per kilogram of weight for all four subjects was 22.3 mg. in comparison with the Sherman standard of 18.9 mg.

Adequacy of the phosphorus in the diets of the women in this study was suggested by unpublished phosphorus balance experiments made by another investigator on the same subjects at three different intervals during the 8-week period. The mean daily phosphorus retention for the four subjects during the balance periods was five milligrams per kilogram of body weight; the mean intake for these periods was 23.1 mg. per kilogram. Similar studies on Chen's (1938) two subjects revealed that both were in negative balance for phosphorus

(unpublished data) on lower intakes, both per capita and per kilogram of weight (19.9 mg. per kg.), and with a larger proportion of the mineral derived from vegetable foods. Since mean intakes for the subjects of both studies were above the Sherman recommendation of 18.9 mg. per kilogram, the negative balance for Chen's group seemed to indicate that more phosphorus was necessary when large amounts were derived from vegetable sources.

The menus, as a whole were colorful and well balanced (Table 2). The cost of the food was moderate, averaging $0.11 per meal for each subject (Table 6).

Meat and fish were served slightly less often than once a day (Table 7). Either eggs, cheese, or dried beans were included in the dietary frequently. Eggs were served less frequently than is usually recommended, but the actual intake was increased by the use of eggs in cooking and baking.

The inclusion of citrus and other fruits (Table 7) in the diet was above the usual standard, but vegetables other than potatoes were served less often than is considered desirable.

The mean daily consumption of milk as a beverage, either as milk or in cocoa, was 1.4 cups per person (Table 9). One

Table 6. Cost of Food - All Subjects.

Week	Cost [1, 2]
1	$ 8.32
2	11.60
3	8.53
4	8.59
5	13.02
6	4.27
7	12.14
8	7.94
Total	74.41

$18.60, per person per 8 weeks
2.33, per person per week
0.333, per person per day
0.111, per person per meal

1. Cost of samples not deducted.

2. Cost includes the value of foods brought from home.

Food	Total servings / subject				Mean serving / subject / day				Standard
	Le	Lu	M	R	Le	Lu	M	R	
Milk, as beverage	52	58	51	58	0.9	1.0	0.9	1.0	2 cups / day
Cocoa, milk	19	16	9	15	0.3	0.3	0.1	0.3	
Ice cream	7	6	6	6	0.1	0.1	0.1	0.1	
Cheese	14	16	14	11	0.3	0.3	0.3	0.2	
Meat and fish	49	51	48	52	0.9	0.9	0.9	0.9	1 serving / day
Eggs	19	21	19	23	0.3	0.4	0.3	0.4	1 / day
Dried legumes	10	11	12	11	0.2	0.2	0.2	0.2	
Whole grains	94	106	71	100	1.7	1.9	1.3	1.8	2 servings / day
Fruits									
Citrus and tomato	56	64	51	58	1.0	1.1	0.9	1.0	1 serving / day
Other	83	82	85	87	1.5	1.5	1.5	1.6	1 serving / day
Vegetables									
Other than potato	82	89	74	76	1.5	1.6	1.3	1.4	2 servings / day
Green	37	33	34	32	0.7	0.6	0.6	0.6	1 serving / day
Yellow	11	17	13	10	0.2	0.3	0.2	0.2	

Table 8. Summary of Eating Habits.

	Subject			
	Le	Lu	M	R
Total meals missed	3	8	20	6
Breakfast	1	7	19	4
Lunch or supper	2	0	1	2
Dinner	0	1	0	0
Number of times food was taken between meals	42	10	56	35
Sweets	25	4	23	24
Fruit	9	2	24	6
Sandwiches	1	1	3	2

Table 9. Summary of Liquid Intakes.

	Subject			
	Le	Lu	M	R
Water intake, av. / day				
Grams	846.6	2223.4	1015.9	634.0
Glasses *	4.6	12.0	5.5	3.4
Milk intake				
Grams	304.0	324.2	251.1	347.2
Cups **	1.27	1.35	1.05	1.45

* 1 glass =○= 185 gm.
** 1 cup =○= 240 gm.

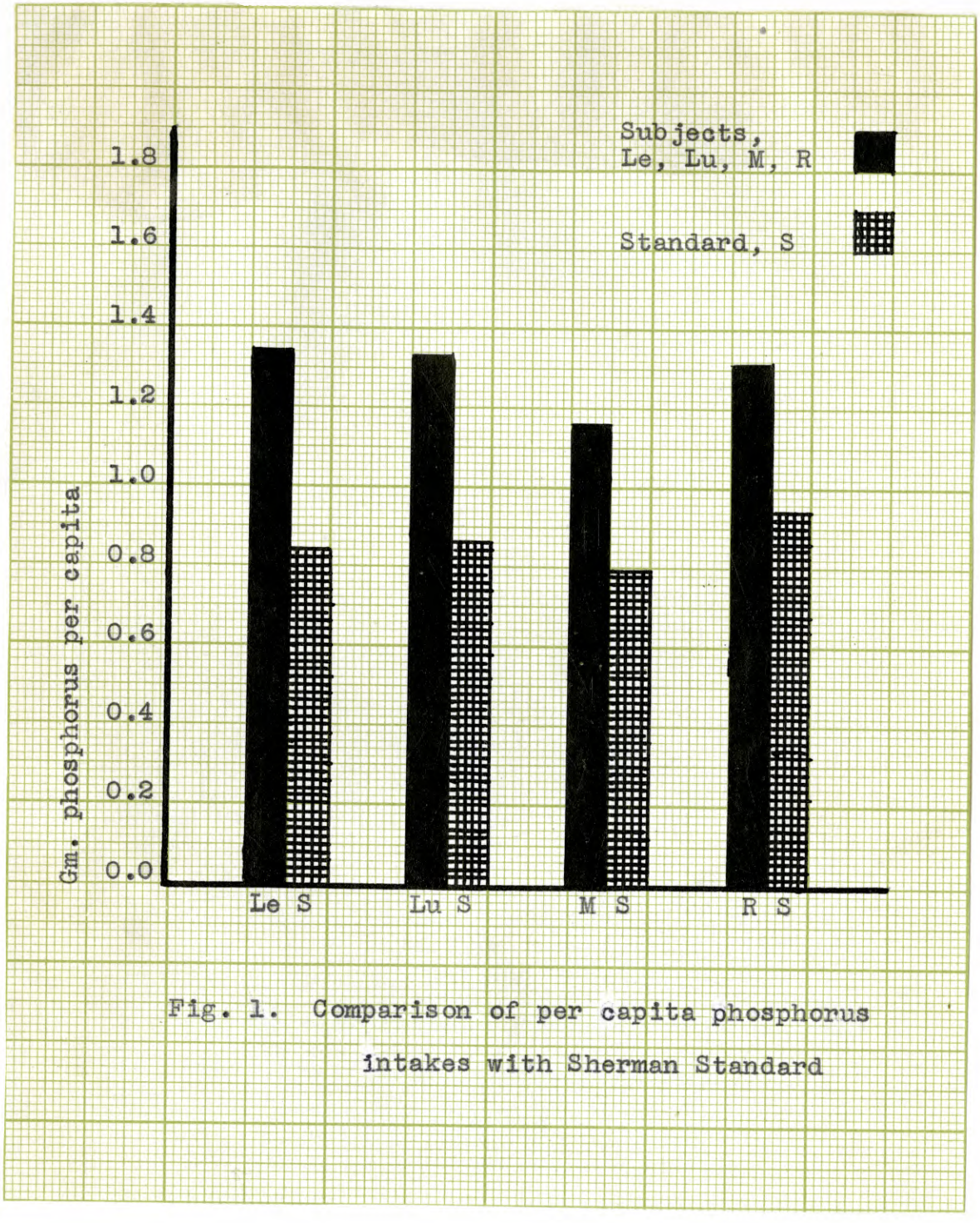

Fig. 1. Comparison of per capita phosphorus intakes with Sherman Standard

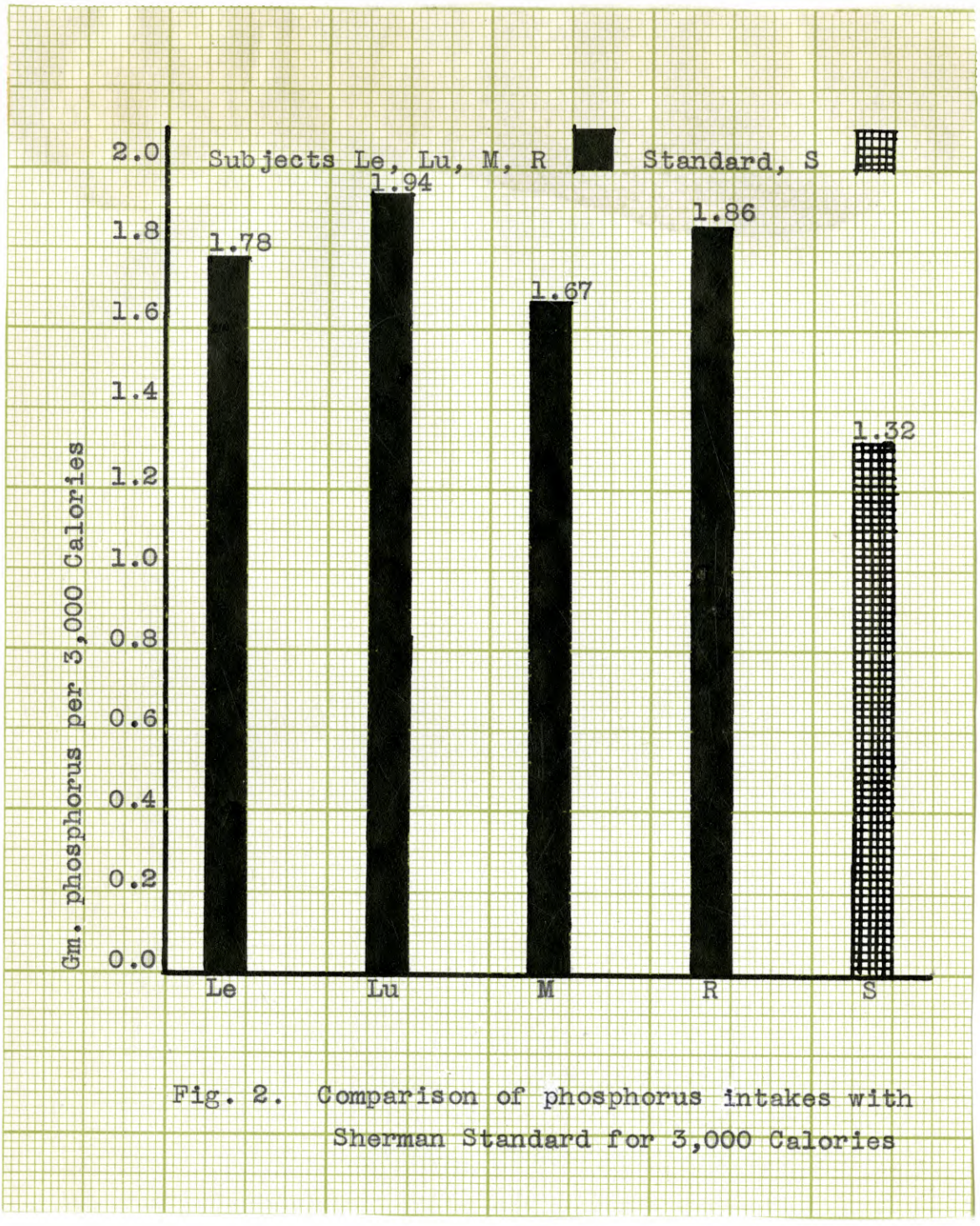

Fig. 2. Comparison of phosphorus intakes with Sherman Standard for 3,000 Calories

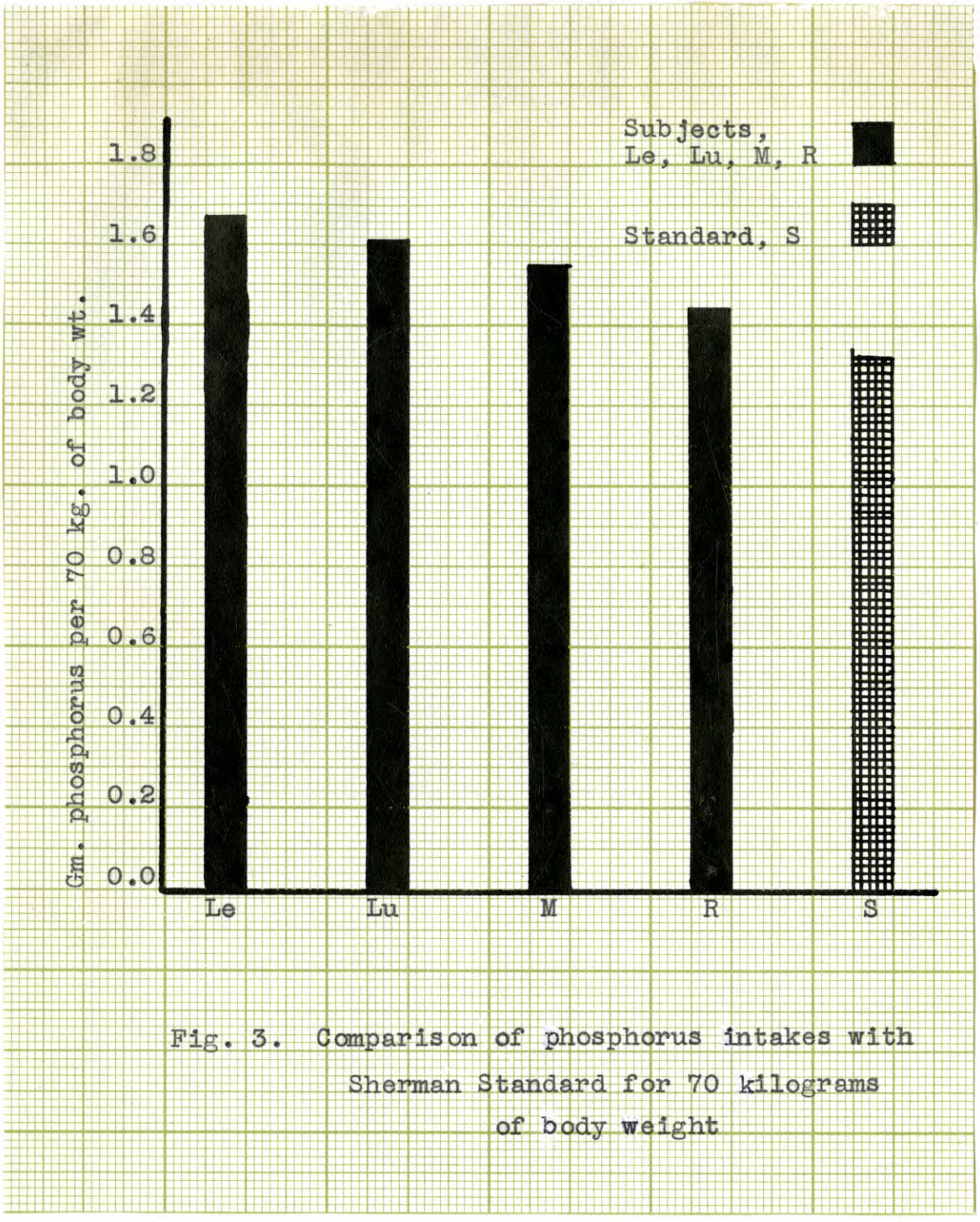

Fig. 3. Comparison of phosphorus intakes with Sherman Standard for 70 kilograms of body weight

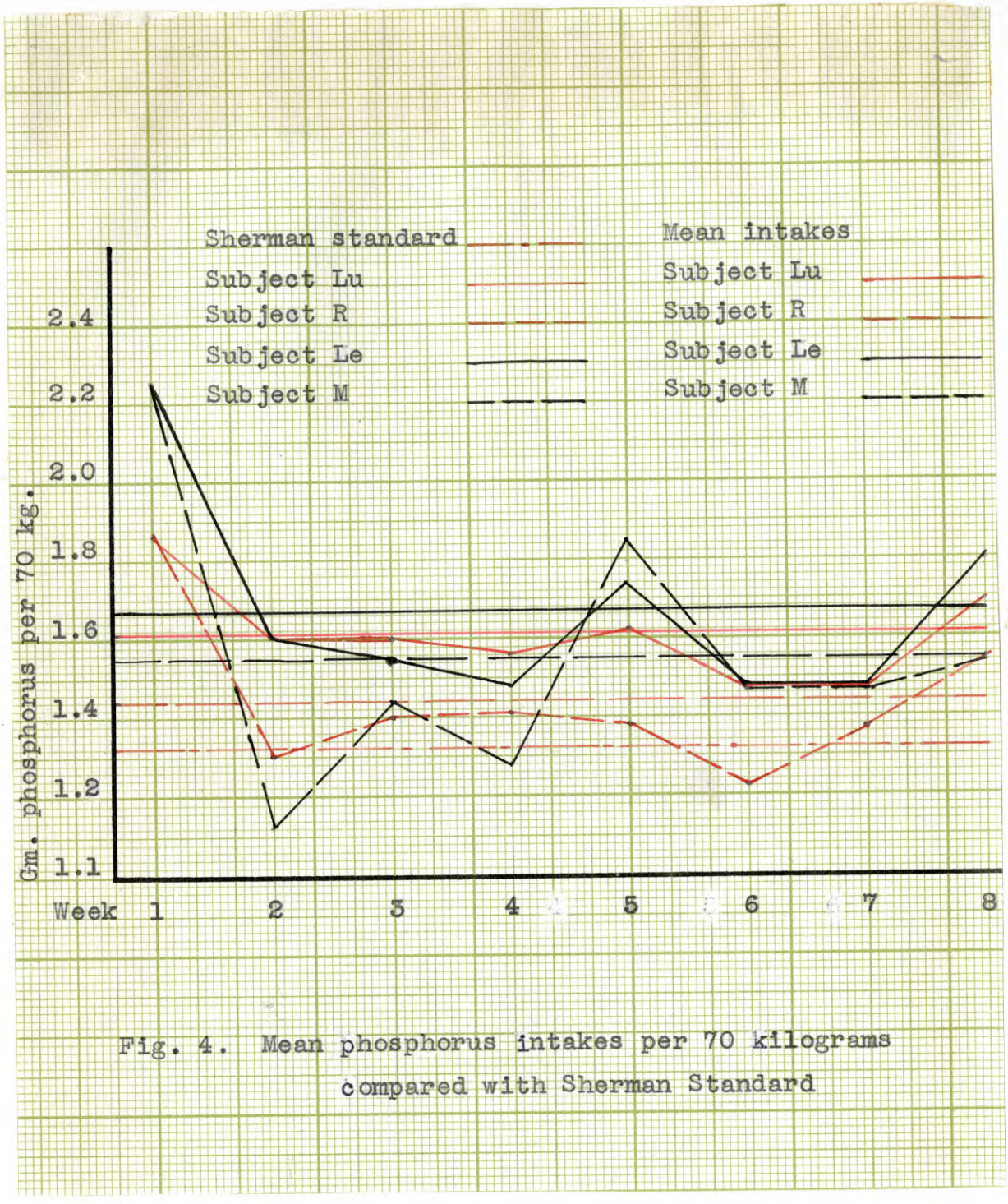

Fig. 4. Mean phosphorus intakes per 70 kilograms compared with Sherman Standard

Table 10. Comparison of Results of this Study with Results of Previous Investigations.

Type of study	Investigator	Year	Institution	Mean phosphorus intakes		
				Per capita	Per 3000 Calories	Per 70 kg.
Group inventory	Borthwick	1917	Montana State College	1.28		
	Kramer and Grundmeier	1926	Kansas State College		1.32	
	Grace	1929	Oregon State College	"Equal to or above standard allowance."		
	Trump	1930	Kansas State College	1.19	1.53	
				1.46	1.60	
	Ryder	1932	Kansas State College	1.197	1.971	2.37
	Shirley	1932	Kansas State College	1.38	1.47	
	Conard	1934	Kansas State College	0.92	1.05	
	Goddard	1934	University of California	1.34	1.09	
				1.15	1.38	
	Jackson	1934	Kansas State College	0.977	1.25	
	Mitchell	1935	Battle Creek College	0.98		
				0.92		
	Wheeler and Mallay	1935	Vassar	1.32	1.65	
	Schermerhorn	1936	Kansas State College	1.13	1.62	1.31
	Atkinson	1937	McPherson College	1.71	1.86	
Survey	Latzke	1934	North Dakota Agricultural College	0.940		
	Morris and Bowers	1939	Utah State Agricultural College	1.103 ± .053		
Analysis of excreta	Kramer et al.	1934	Kansas State College			1.39
						1.40
	Kramer and Gillum	1938	Kansas State College			1.26
Individual weighed dietary	Coons and Schiefelbusch	1932	Oklahoma Agricultural and Mechanical College	1.19	1.79	
	Chen	1938	Kansas State College	0.996	1.737	1.452
				1.063	1.596	1.487
	This study	1939	Kansas State College	1.162	1.666	1.552
				1.313	1.863	1.438
				1.325	1.935	1.606
				1.338	1.783	1.671
			Standard	1.32	1.32	1.32

subject consumed considerably less than the others and this mean, the chief reason being that she often omitted breakfast. Considering the frequency of the use of milk in cooking, the average daily intake appeared to be approximately one pint.

CONCLUSIONS

The subjects of this study, having some knowledge of foods and nutrition, were able to choose colorful, interesting, and inexpensive diets that were apparently abundant in phosphorus and fairly well balanced in other respects.

The chief sources of phosphorus in the diets were milk, meat, fish, cheese, eggs, dried beans, and whole grain products.

No direct relation between caloric value and phosphorus content of the diets was apparent, although increased phosphorus was found in about one-fourth of the cases of higher energy intake.

The results of this study suggest that these women, when allowed to choose their diets, used even larger amounts of phosphorus than are commonly recommended for the 70 kg. adult male unit. The data, however, were insufficient to determine the amounts actually needed by college women.

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