PHOSPHORUS INTAKE OF COLLEGE WOMEN AS INDICATED BY PHOSPHORUS OUTPUT

by

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INTRODUCTION

The kinds and amounts of food needed to furnish sufficient phosphorus in the diet of the human adult have been investigated and accepted figures are available for the phosphorus standard and requirement per 70 kilograms of body weight per day. Group dietary studies are sometimes used to show trends and estimates of intake for selected groups of people but cannot give accurate data for the individual. Weighed dietary studies are used for exact determinations of the individual intake but the subject's free choice of food is more or less affected. Few investigations have been made to check actual diets and to compare them with accepted standards. For phosphorus this may be done without affecting the free choice of food by determining the output since phosphorus output of the normal adult is an indication of phosphorus intake.

REVIEW OF LITERATURE

Sherman (10) has found that the phosphorus requirement per 70 kilograms of body weight averages 0.88 gram per day. As this represents the minimal level a safety factor of 50 per cent has been added thus raising the standard to 1.32 grams per 70 kilograms of body weight. This is the standard

generally accepted at the present time.

Studies are sometimes made to learn of the nutritive value, including phosphorus content, of diets actually consumed by people in various situations. Inventory studies are often used for families or other groups living together. Data so obtained are valuable but of course do not show actual food consumption. Such a study, which included phosphorus, was made by Gillett and Rice (5) to determine the influence of education upon the food habits of some New York families. They found the phosphorus content of the diet of the average family to be above the standard after more abundant milk and milk products had been included. However, some of the families failed to meet the Sherman requirement for phosphorus. Muse and Gillum (9) made an inventory dietary study with 50 Vermont farm households using Hawley's (6) short method of calculation for calories, protein, calcium, phosphorus and iron, then deducting 10 per cent for waste. They found 72 per cent of the families were meeting their phosphorus standard and the average phosphorus intake per 70 kilograms of body weight was 1.62 grams per day. Another example of this type of study was carried on by McKay and Brown (7) with a group of rural families in Ohio over a 3-year period. Eight out of 18 families were using less than the recommended amount of phosphorus although the

average for the group was 1.65 grams of phosphorus per day per 70 kilograms of body weight. This study also showed the lower cost dietaries to be least adequate in phosphorus.

Survey or questionnaire dietary studies are sometimes used when more accurate information cannot be secured. Such an investigation was made by Winters (12) with 65 Mexican families in Texas. She found 54 per cent of the diets below standard for phosphorus. Studies of this kind might serve to indicate considerable variation between different groups.

Weighed dietary studies yield accurate information regarding the intake of the individual. McLaughlin et al (8) studied the food intake of six preschool children. Equivalent weighed samples of all food eaten by the children were analyzed and the phosphorus intake was found to average 1.13 grams. Shukers and others (11) worked with lactating women. The food selected by the women was weighed and its composition calculated. The milk was expressed at regular intervals and analyses made on 24-hour composite samples to determine the amount of phosphorus excreted in the milk. The phosphorus intake was found to average 3.25 grams. The loss in the milk was found to be approximately 9.3 per cent and a surplus of approximately 0.042 gram per kilogram of body weight was reported. A third example of this type of investigation was reported by Coons et al (2) in a study of

the diets of college women in relation to basal metabolism. Self chosen diets were used. The food was weighed and samples for analysis were collected at the time the food was consumed. With this group the phosphorus intake was low, with nearly one-third of the subjects receiving less than 1.0 gram daily. The dietaries were reported low in milk, eggs and meat.

EXPERIMENTAL PROCEDURE

The present investigation was planned to study the phosphorus intake of college women as indicated by phosphorus output. Unless the intake is at a very low level the normal adult tends to adjust his phosphorus metabolism to his phosphorus supply so that studies of the phosphorus eliminated are an indication of the phosphorus intake. This study seemed of value to add to the rather scanty data already existing relative to the actual phosphorus intake of college women.

Twenty-five college women, 11 graduate and 14 undergraduate, served as subjects for Series I of this experiment. This group included women eating at the college cafeteria, at home, in boarding houses, sorority houses and at the dormitory. In each case they were requested to follow their customary activities and eating habits and to keep daily

records of their activities and food intake on record sheets provided for this purpose. In most cases the subjects were not informed as to the exact nature of the experiment lest it influence their choice of food. For a 4-day period in the fall and a 4-day period in the winter complete collections were made of urine and feces.

Five college women, three graduate and two undergraduate students, served as subjects for the periods of Series II. For one 4-day period samples were collected while the subjects were eating their usual freely chosen diets. Subsequently the subjects collected samples during 4-day periods when the meals were freely chosen except that specific foods were omitted. For one period milk or cheese or foods containing large amounts of these were omitted. For the next period, the subjects refrained from eating any high protein foods of animal origin, including milk, cheese, ice cream, meat, fish, poultry and eggs. In order that these experiments might be reliable, subjects were asked to observe a 3-day fore period before the collection of samples for the periods with imposed restrictions.

Throughout the entire experiment the urine collections were divided into 24-hour units from 7:00 A.M. to 7:00 A.M. and the feces were marked with carmine at the beginning and end of the period. The feces were dried at low temperature to a constant weight, weighed, pulverized and stored in air-

Date _____

Name _____

	Where Eaten	Foods Eaten	Approx. Amt.	Calculations
Breakfast				
Lunch				
Dinner				
Between Meals				

Date _____

Name _____

Time	Activity	No. of Minutes

tight glass bottles. The urine for each day was measured and a composite sample saved for analysis.

Quantitative determinations for phosphorus were made upon 10 cc. of urine and 0.5 gram of dried feces for each subject for each period, using the volumetric method of the Association of Official Agricultural Chemists (1). All determinations were made in duplicate. The sum of the weight of phosphorus excreted per day in the urine and the weight excreted per day in the feces represented the total daily output of phosphorus. These figures were reduced to average daily phosphorus excretion per 70 kilograms of body weight as a means of standardization.

Daily food lists which had been kept by the subjects were checked in an effort to find the relationships between food consumed and phosphorus used. Special attention was given to milk and cheese, meat, fish, poultry and eggs, whole grain products and dried legumes.

DISCUSSION

Tables I and II show the data as computed for each subject of Series I for the 4-day period in the fall and again in the winter. There were distinct variations among individuals. Minimum, maximum and average figures are:

TABLE I

DATA FOR PERIOD I - FALL

Series I

Subject Initials	Average weight kilo.	Volume urine cc.	P 10 cc. grams	Total P urine grams	Weight feces dried grams	P - 1 gm. grams	Total P feces grams	Total P per day grams	Total P 4-day period grams
1. ML	49.0	5050	0.0040	0.51	114.0	0.01714	0.33	1.00	4.00
2. RMc	73.5	4505	0.0070	0.79	100.5	0.02057	0.60	1.31	5.24
3. RC	56.2	5820	0.0027	0.30	110.5	0.01682	0.44	0.77	3.08
4. ME	54.4	5515	0.0094	0.52	126.0	0.03162	0.54	1.52	6.08
5. WJ	49.9	5175	0.0060	0.77	73.8	0.02653	0.64	1.26	5.04
6. SM	58.1	2490	0.0232	0.58	87.0	0.02533	0.78	0.86	3.44
7. GJ	52.2	5290	0.0045	0.60	74.0	0.02362	0.39	1.04	4.16
8. HB	55.3	7770	0.0076	0.59	86.0	0.01889	0.56	1.00	4.00
9. GB	57.6	2965	0.0113	0.84	116.5	0.01582	0.43	1.30	5.20
10. FH	70.3	3250	0.0089	0.84	109.5	0.01447	0.44	1.24	4.96
11. LR	51.7	6590	0.0035	0.58	93.0	0.02289	0.49	1.11	4.44
12. LG	56.7	4775	0.0054	0.65	91.5	0.03087	0.45	1.36	5.44
13. HD	57.2	7810	0.0028	0.41	99.5	0.02363	0.56	1.00	4.00
14. IG	57.6	8895	0.0026	0.57	142.0	0.01723	0.43	1.18	4.72
15. NS	56.7	4525	0.0057	0.65	109.0	0.02296	0.64	1.28	5.12
16. HE	56.2	3900	0.0065	0.63	95.0	0.03319	0.41	1.02	4.08
17. EF	58.1	3125	0.0084	0.65	68.5	0.01724	0.33	0.95	3.80
18. SS	48.1	5790	0.0114	0.66	89.5	0.02428	0.40	1.20	4.80
19. MR	58.5	2730	0.0086	0.59	54.0	0.01909	0.33	0.85	3.40
20. EN	42.6	3500	0.0172	0.60	29.5	0.02446	0.29	0.78	3.12
21. ZL	60.3	3915	0.0142	0.56	91.0	0.01950	0.55	1.00	4.00
22. AB	55.3	3180	0.0101	0.80	61.0	0.01705	0.19	1.06	4.24
23. RR	57.7	6100	0.0086	0.53	99.0	0.01855	0.50	1.00	4.00
24. DB	54.0	3195	0.0101	0.81	77.0	0.01745	0.32	1.15	4.60
25. ZMc	62.1	4560	0.0080	0.91	131.5	0.02025	0.52	1.58	6.32
Average	56.1	4816	0.0082	0.63	93.2	0.02157	0.46	1.11	4.45

TABLE II

DATA FOR PERIOD II - WINTER

Series I

Subject Initials	Average weight kilo.	Volume urine cc.	P 10 cc. grams	Total P urine grams	Weight feces dried grams	P - 1 gm. grams	Total P feces grams	Total P per day grams	Total P 4-day period grams
1. ML	49.9	4390	0.0054	0.59	74.5	0.01762	0.33	0.92	3.68
2. RMc	73.9	4230	0.0085	0.90	112.0	0.02152	0.60	1.50	6.00
3. RC	55.8	7730	0.0036	0.69	74.0	0.02358	0.44	1.13	4.52
4. ME	56.2	4390	0.0120	0.53	85.5	0.02536	0.54	1.07	4.28
5. WJ	50.8	4225	0.0087	0.91	101.0	0.02542	0.64	1.55	6.20
6. SM	59.0	3515	0.0175	0.62	126.5	0.02461	0.78	1.40	5.60
7. BJ	54.9	3310	0.0082	0.68	66.0	0.02439	0.39	1.07	4.28
8. HB	56.2	6590	0.0095	0.63	105.0	0.02135	0.56	1.19	4.76
9. GB	59.4	3080	0.0113	0.87	80.0	0.02124	0.43	1.30	5.20
10. FH	68.5	3765	0.0079	0.75	86.0	0.02058	0.44	1.19	4.76
11. LR	53.0	5925	0.0040	0.58	76.0	0.02598	0.49	1.07	4.28
12. LG	58.5	3660	0.0076	0.69	95.0	0.01880	0.45	1.14	4.56
13. HD	59.0	10405	0.0024	0.64	96.0	0.02339	0.56	1.20	4.80
14. IG	63.0	5946	0.0041	0.61	74.0	0.02330	0.43	1.04	4.16
15. NS	58.1	4050	0.0070	0.71	104.5	0.02441	0.64	1.35	5.40
16. HE	57.2	2840	0.0081	0.58	95.5	0.01728	0.41	0.99	3.96
17. EF	59.4	3450	0.0098	0.85	57.0	0.02250	0.33	1.18	4.72
18. SS	55.8	6030	0.0122	0.73	79.5	0.02095	0.43	1.15	4.60
19. MR	58.5	2670	0.0080	0.48	64.0	0.02071	0.33	0.81	3.24
20. EN	43.1	4810	0.0154	0.74	51.5	0.02249	0.29	1.03	4.12
21. ZL	62.1	3970	0.0168	0.67	125.0	0.01774	0.55	1.22	4.88
22. AB	55.8	3260	0.0082	0.67	45.0	0.01649	0.19	0.86	3.44
23. RR	51.7	7160	0.0072	0.51	94.5	0.02098	0.50	1.01	4.04
24. DB	54.0	2970	0.0084	0.61	39.5	0.03196	0.32	0.93	3.72
25. ZMc	64.4	3810	0.0088	0.85	83.0	0.02513	0.52	1.37	5.48
Average	57.5	4647	0.0088	0.68	84.3	0.02207	0.46	1.15	4.59

		Wt. of sub-jects Kg.	Urine: Total volume cc.	Urine: P. in 10 cc. gm.	Urine: Total P. gm.	Feces: Wt. of dry feces gm.	Feces: P. in 1.0 gm. gm.	Feces: Total P gm.
Fall	Min.	42.6	2490	0.0026	0.30	29.5	0.01447	0.19
	Max.	73.5	8895	0.0232	0.91	142.0	0.03319	0.78
	Av.	56.1	4816	0.0082	0.63	93.2	0.02157	0.46
Winter	Min.	43.1	2670	0.0024	0.48	39.5	0.01649	0.19
	Max.	73.9	10405	0.0175	0.91	126.5	0.03196	0.78
	Av.	57.5	4647	0.0882	0.68	84.3	0.02207	0.46

Table III shows averages for the two periods. For each subject in each period the average daily phosphorus output is expressed first in actual grams of phosphorus eliminated and then as reduced to terms of 70 kilograms of body weight. The latter calculation was necessary in order to make comparisons within the group and with the accepted figures of Sherman (10). Maximum, minimum and average figures are:

TABLE III

PHOSPHORUS OUTPUT PER DAY

Series I

Subject Initials	Period I: Average daily Phosphorus grams	Period I: Av. P daily per 70 kilo. grams	Period II: Average daily Phosphorus grams	Period II: Av. P daily per 70 kilo. grams
1. ML	1.00	1.43	0.92	1.29
2. RMc	1.31	1.25	1.50	1.42
3. RC	0.77	0.96	1.13	1.42
4. ME	1.52	1.96	1.07	1.33
5. WJ	1.26	1.77	1.55	2.14
6. SM	0.86	1.04	1.40	1.66
7. BJ	1.04	1.39	1.07	1.36
8. HB	1.00	1.27	1.19	1.48
9. AB	1.30	1.58	1.30	1.53
10. FH	1.24	1.23	1.19	1.22
11. LR	1.11	1.49	1.07	1.41
12. LG	1.36	1.68	1.14	1.36
13. HD	1.00	1.22	1.20	1.42
14. IG	1.18	1.43	1.04	1.16
15. NS	1.28	1.58	1.35	1.63
16. HE	1.02	1.27	0.99	1.21
17. EF	0.95	1.14	1.18	1.39
18. SS	1.20	1.75	1.15	1.44
19. MR	0.85	1.02	0.81	0.97
20. EN	0.78	1.28	1.03	1.67
21. ZL	1.00	1.16	1.22	1.38
22. AB	1.06	1.34	0.86	1.08
23. RR	1.00	1.35	1.01	1.37
24. DB	1.15	1.49	0.93	1.21
25. ZMc	1.58	1.78	1.37	1.49
Averages	1.11	1.39	1.15	1.40

		Daily Output of P	
		Actual: gm.	Per 70 kilo. gm.
Fall	Minimum:	0.77	0.96
	Maximum:	1.58	1.98
	Average:	1.11	1.39
Winter:	Minimum:	0.81	0.97
	Maximum:	1.55	2.14
	Average:	1.15	1.40

When expressed on the basis of 70 kilograms of body weight both periods gave average figures slightly above the Sherman standard of 1.32 grams.

Figures 1 and 2 show the graphic distribution of the subjects in relation to the Sherman (10) requirement and standard for phosphorus. The various subjects are indicated by the same numbers assigned to them in Table I and location on the graph is based upon the amount of phosphorus eliminated and the body weight.

In the fall period figures for 18 of the 25 subjects were above the Sherman standard of 1.32 grams of phosphorus per 70 kilograms. Figures for the other subjects were between the Sherman standard and the Sherman requirement of 0.88 gram of phosphorus per 70 kilograms of body weight.

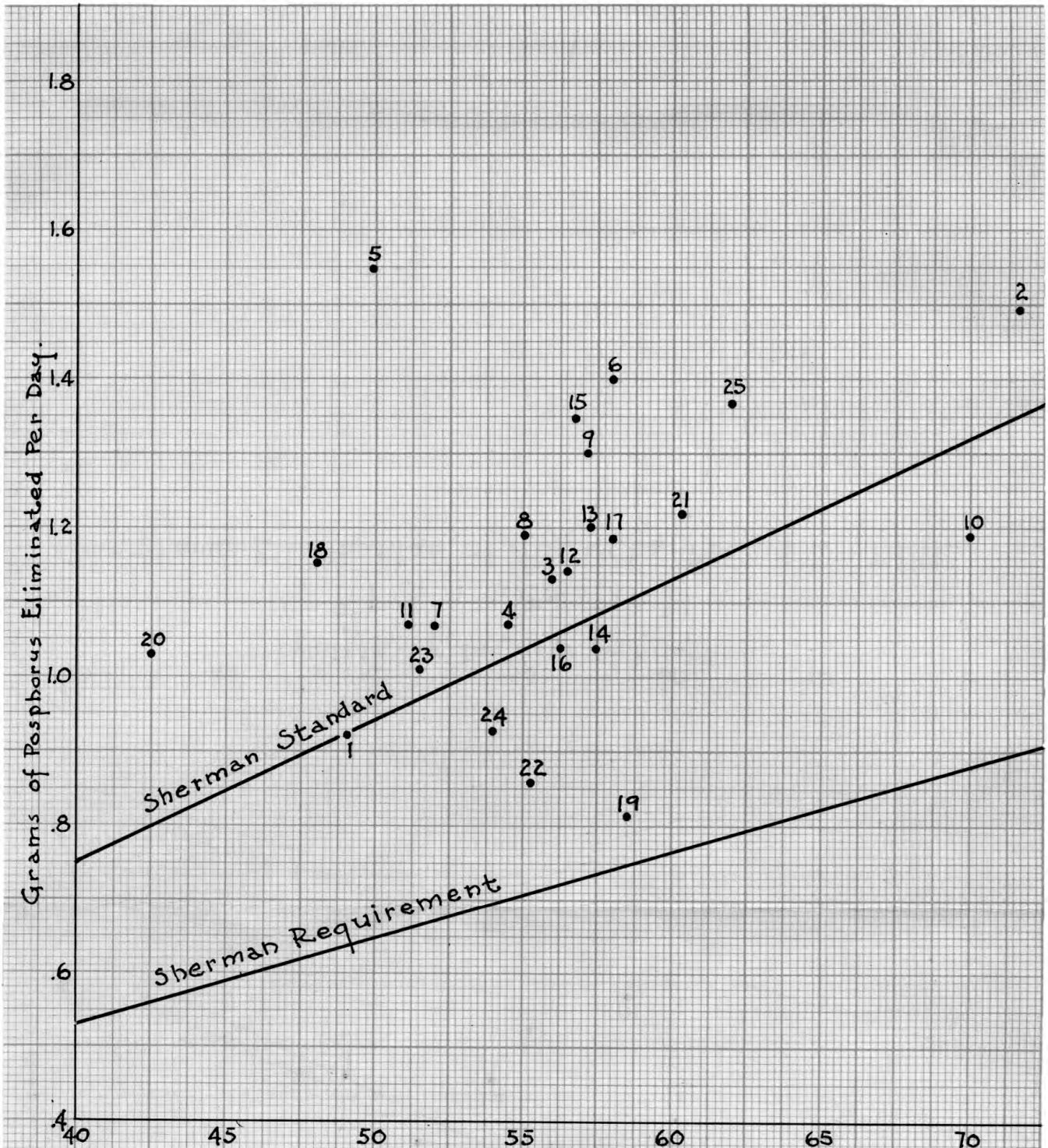


FIG. 1. (SERIES I)

Phosphorus Elimination of Subjects-Period I. - Fall.

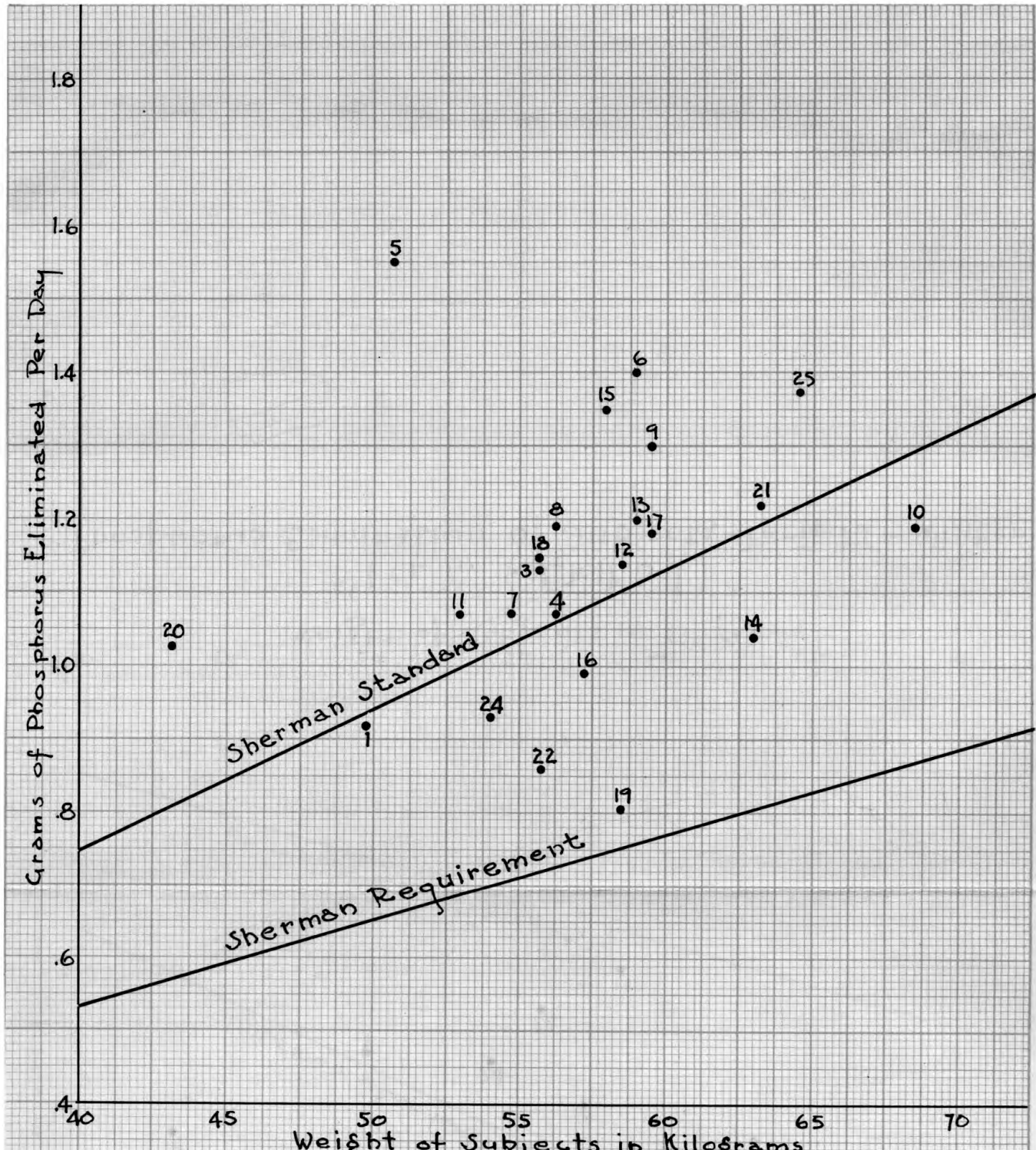


FIG. 2. (SERIES I)
Phosphorus Elimination of Subjects,-Period II - Winter

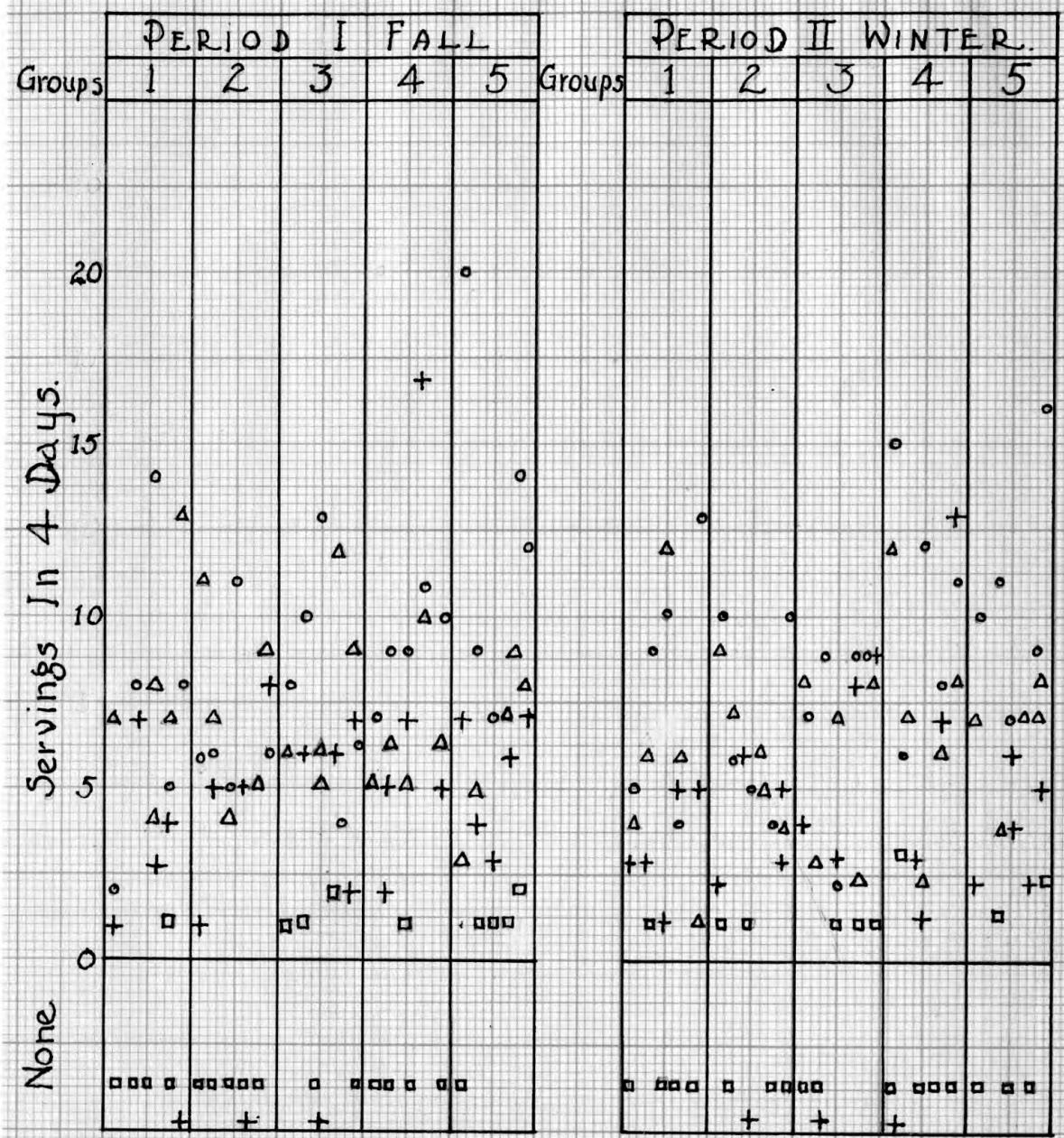
During the winter period the outputs of these same seven subjects fell below the standard but were still above the requirement, probably suggesting that their customary diet was low in phosphorus. Figures for the remaining 18 subjects were still above the Sherman standard in the winter period. It is worthy of note that the phosphorus outputs for all the subjects tested were found to be above the requirement and the majority of the group were receiving phosphorus well in excess of that amount which Sherman has set up as a dietary standard.

Nitrogen and calcium outputs for the same 25 subjects for the same periods had previously been determined by Evers (3) and Gallemore (4). Relationships between the figures were studied. In general, it seems that a subject showing low figures for one nutritive factor was likely to have low figures elsewhere. The opposite was also true. Subjects having adequate supplies of calcium were likely to have good amounts of phosphorus, and vice versa, the coefficients of correlation between the amounts of calcium and phosphorus being 0.94 (a nearly perfect correlation) for the fall period and 0.78 (a good correlation) for the winter period. Some direct correlation also exists between the amounts of protein and of phosphorus, the coefficients of correlation being 0.55 for the fall period and 0.61 for the winter period.

Figure 3 was made to show the relationship between the amount of phosphorus eliminated and the incidence of phosphorus rich foods reported in the diet. The subjects were divided into five groups based upon the amount of phosphorus eliminated. Group 1 represented the low group and Group 5 the highest. The numbers of servings of milk and cheese, meat, fish, poultry and eggs, dried legumes and whole grain products were represented by special symbols placed graphically for each individual in each group for both the fall and winter periods. These symbols show the recorded number of servings of each of these foods known to be high in phosphorus. The high groups reported a somewhat larger number of servings of high phosphorus foods. This was especially true with milk and cheese.

Table IV shows a comparison of those subjects having a free choice of food and those eating set meals in regard to the number of reported servings of foods high in phosphorus. Eight of the 25 subjects were eating freely chosen meals and 17 were eating meals as served at home, boarding house, dormitory or sorority house. Of those subjects who were eating freely chosen meals, half had phosphorus figures above the standard and half figures below the standard. Of the group eating set meals, 14 subjects had figures above the standard and three had figures below the standard. The

Subjects Divided into Five Groups According to Elimination of Phosphorus. Group I Being the Lowest.



•Milk and Cheese. △Meat, Fish, Poultry and Eggs. Dried Legumes
+Whole Grain Products.

FIG. 3. (SERIES I)
Reported Servings of High Phosphorus Foods In 4 Days.

TABLE IV

REPORTED SERVINGS OF HIGH PHOSPHORUS FOODS

Series I

Amount of Phosphorus	Subjects having free choice of food					Subjects eating set meals				
	No. of Subjects	Average serving per subject				No. of Subjects	Average serving per subject			
		Milk and cheese	Dried legumes	Meat, fish poultry, eggs.	Whole grain products		Milk and cheese	Dried legumes	Meat, fish poultry eggs	Whole grain products
Above Sherman Standard	4	12.0	0.25	4.5	4.0	14	8.8	0.6	7.3	5.6
Sherman Standard to Sherman Minimum	4	9.0	0.0	9.0	2.7	3	4.3	0.3	7.0	3.3
Below Sherman Minimum	0	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0
Period II Above Sherman Standard	4	9.5	0.0	6.0	2.5	14	8.7	0.7	6.2	4.7
Sherman Standard to Sherman Minimum	4	10.5	0.5	7.0	2.7	3	5.0	0.0	5.6	4.6
Below Sherman Minimum	0	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0

distribution of the above groups also carried over into the winter period. With a few exceptions, those persons showing high phosphorus elimination reported more servings of foods high in phosphorus. Possible discrepancies might be accounted for by the fact that little record was kept of the size of the servings and the food intake was therefore not always accurately reported.

Table V is used to show a possible correlation between the plan of food service and the amount of phosphorus eliminated by the 25 subjects in Series I. The figures obtained were not very consistent and would seem to show that in this study, at least, the plan of food service had little effect on the phosphorus used.

Tables VI, VII and VIII show the data for Series II, as computed for each subject for the 4-day periods during the summer. Minimum, maximum and average figures for the customary diet, milk free diet and animal protein free diet are:

TABLE V

PHOSPHORUS ELIMINATION AS RELATED TO PLAN OF FOOD SERVICE

Series I

	Average Phosphorus per 70 kilograms per Day		
	Period I - Fall	Period II - Winter	Average
All subjects	1.394	1.402	1.398
Subjects choosing food	1.377	1.460	1.418
Subjects eating set meals	1.432	1.277	1.354

TABLE VI

DATA FOR PERIOD I - CUSTOMARY DIET

Series II

Subject	Average weight	Volume urine	P 10 cc.	Total P urine	Weight feces dried	P - 1 gm.	Total P feces	Total P 1-day period	Total P 4-day period
26. MF	72	5935	0.0048	0.71	69.0	0.0117	0.37	1.08	4.32
27. AG	54	2785	0.0098	0.68	66.5	0.0118	0.20	0.88	3.42
28. LMc	60	3715	0.0081	0.75	194.6	0.0224	1.09	1.84	7.36
29. HP	63	6835	0.0044	0.76	123.3	0.0184	0.57	1.33	5.32
30. MW	62	5010	0.0059	0.74	33.7	0.0227	0.19	0.93	3.72
Average	62	4856	0.0066	0.73	97.3	0.0174	0.84	1.21	4.83

TABLE VII

DATA FOR PERIOD II - MILK FREE DIET

Series II

Subject	Average weight	Volume urine	P 10 cc.	Total P urine	Weight feces dried	P - 1 gm.	Total P feces	Total P 1-day period	Total P 4-day period
26. MF	72	5395	0.0038	0.51	89.0	0.0156	0.35	0.86	3.44
27. AG	54	4045	0.0061	0.62	57.1	0.0125	0.18	0.90	3.60
28. LMc	60	6480	0.0042	0.68	69.5	0.0131	0.24	0.92	3.68
29. NP	63	6720	0.0038	0.63	121.0	0.0191	0.58	1.21	4.84
30. MW	62	4390	0.0050	0.55	96.0	0.0180	0.43	0.98	3.92
Average	62	5406	0.0046	0.60	86.5	0.0157	0.35	0.97	3.69

TABLE VIII

DATA FOR PERIOD III - ANIMAL PROTEIN FREE

Series II

Subject	Average weight	Volume urine	P 10 cc.	Total P urine	Weight feces dried	P - 1 gm.	Total P feces	Total P 1-day period	Total P 4-day period
26. MF	71	3990	0.0045	0.45	64.1	0.0166	0.26	0.71	2.84
27. AG*	54	975	0.0114	0.45	62.7	0.0111	0.35	0.80	3.20
30. MW	62	2600	0.0060	0.38	51.0	0.0199	0.25	0.63	2.52
Average	62	2522	0.0073	0.43	59.3	0.0158	0.29	0.71	2.85

* 2 day period only.

		Wt. of subject Kg.	Urine: Total vol. cc.	Urine: P in 10 cc. grams	Urine: Total P grams	Feces: Wt. of dry feces grams	Feces: P in 1 gm. grams	Feces: Total P grams
Customary	Min.	54	2785	0.0044	0.68	33.7	0.0117	0.19
	Max.	72	6835	0.0098	0.76	194.6	0.0224	1.09
	Av.	62	4856	0.0066	0.73	97.4	0.0174	0.48
No milk	Min.	54	4045	0.0038	0.51	57.1	0.0125	0.18
	Max.	72	6720	0.0061	0.68	121.0	0.0191	0.58
	Av.	62	5406	0.0046	0.60	86.5	0.0157	0.35
No animal protein	Min.	54	975	0.0045	0.38	51.0	0.0111	0.25
	Max.	71	3990	0.0114	0.45	64.1	0.0199	0.35
	Av.	62	2522	0.0073	0.43	59.3	0.0158	0.29

Table IX shows averages for the periods in the summer experiment. For each subject in each period the average daily phosphorus output is first expressed in actual grams of phosphorus eliminated and then as reduced to terms of 70 kilograms of body weight. Maximum, minimum and average figures are:

TABLE IX

PHOSPHORUS OUTPUT PER DAY

Series II

Subject Initials	Period I		Period II		Period III	
	Average daily phosphorus grams	Average P daily per 70 kilo. grams	Average daily phosphorus grams	Average P daily per 70 kilo. grams	Average daily phosphorus grams	Average P daily per 70 kilo. grams
26. MF	1.08	1.05	0.86	0.84	0.71	0.70
27. AG	0.88	1.15	0.90	1.17	0.80	1.04
28. LMc	1.84	2.15	0.92	1.07		
29. HP	1.33	1.48	1.21	1.34		
30. MW	0.93	1.05	0.98	1.11	0.63	0.71
Averages	1.21	1.40	0.97	1.11	0.71	0.82

		Daily Output of P	
		Actual: grams	Per 70 Kilo. grams
Period I	Minimum:	0.88	1.05
	Maximum:	1.84	2.15
	Average:	1.21	1.40
Period II	Minimum:	0.86	0.84
	Maximum:	1.21	1.34
	Average:	0.97	1.11
Period III	Minimum:	0.63	0.70
	Maximum:	0.80	1.04
	Average:	0.71	0.82

It is worthy of note that the average for the first period is similar to the averages for the fall and winter periods of Series I. When milk and milk products are excluded the averages fall and when all animal proteins are taken out they fall still lower. Period I shows an average above the Sherman standard, Period II below the Sherman standard, but above his requirement and Period III falls below the requirement.

Figure 4 shows the graphic distribution of the subjects during the summer periods, represented by using a different symbol for each period. The various subjects are indicated by the same numbers assigned to them in Table VI. The graph

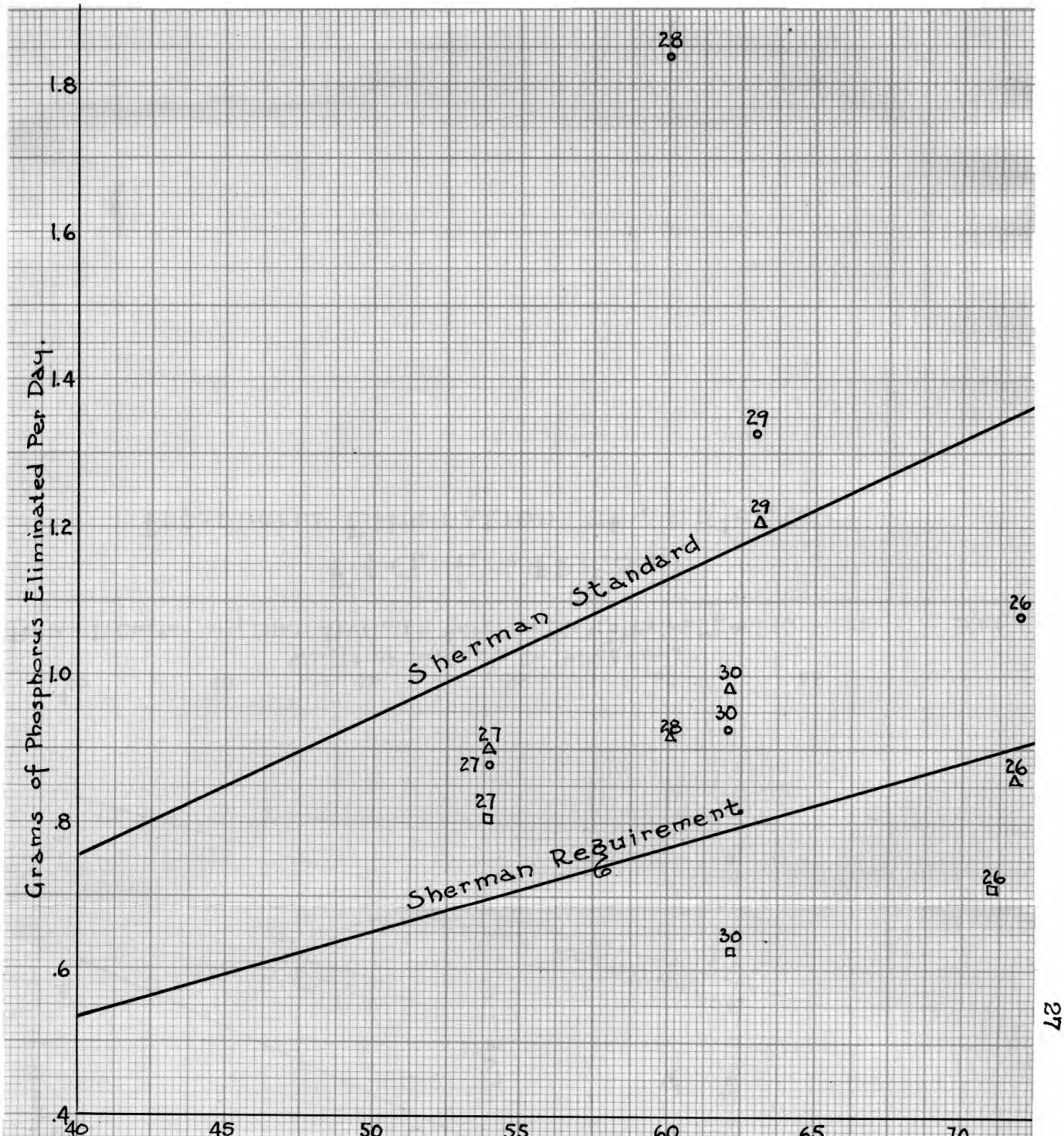


FIG. 4. (SERIES II)

Phosphorus Elimination of Subjects.

is based upon the actual amounts of phosphorus eliminated and the individual body weights.

When eating the regular freely chosen diet, figures for two of the subjects were above the Sherman (10) standard and for three subjects were below the standard but above the requirement. In the second period when milk and milk products were eliminated from the regular diet the output for one subject was barely above the standard, for three subjects the outputs were between the requirement and the standard allowance and for one subject was below the requirement. When all animal proteins were eliminated figures for two of the subjects fell below the requirement while for one subject the result was slightly above. Only three subjects were used in this last period. These figures show the value of high protein foods of animal origin for maintaining an adequate supply of phosphorus in the diet.

Figure 5 shows the occurrence of phosphorus rich foods in the various periods. There is a marked decrease in their frequency in the more restricted diets. When this figure is compared with the amount of phosphorus eliminated the same decrease is apparent in both.

Table X shows the reported number of servings of high phosphorus foods for the various subjects when grouped according to the Sherman standard and requirement. In most

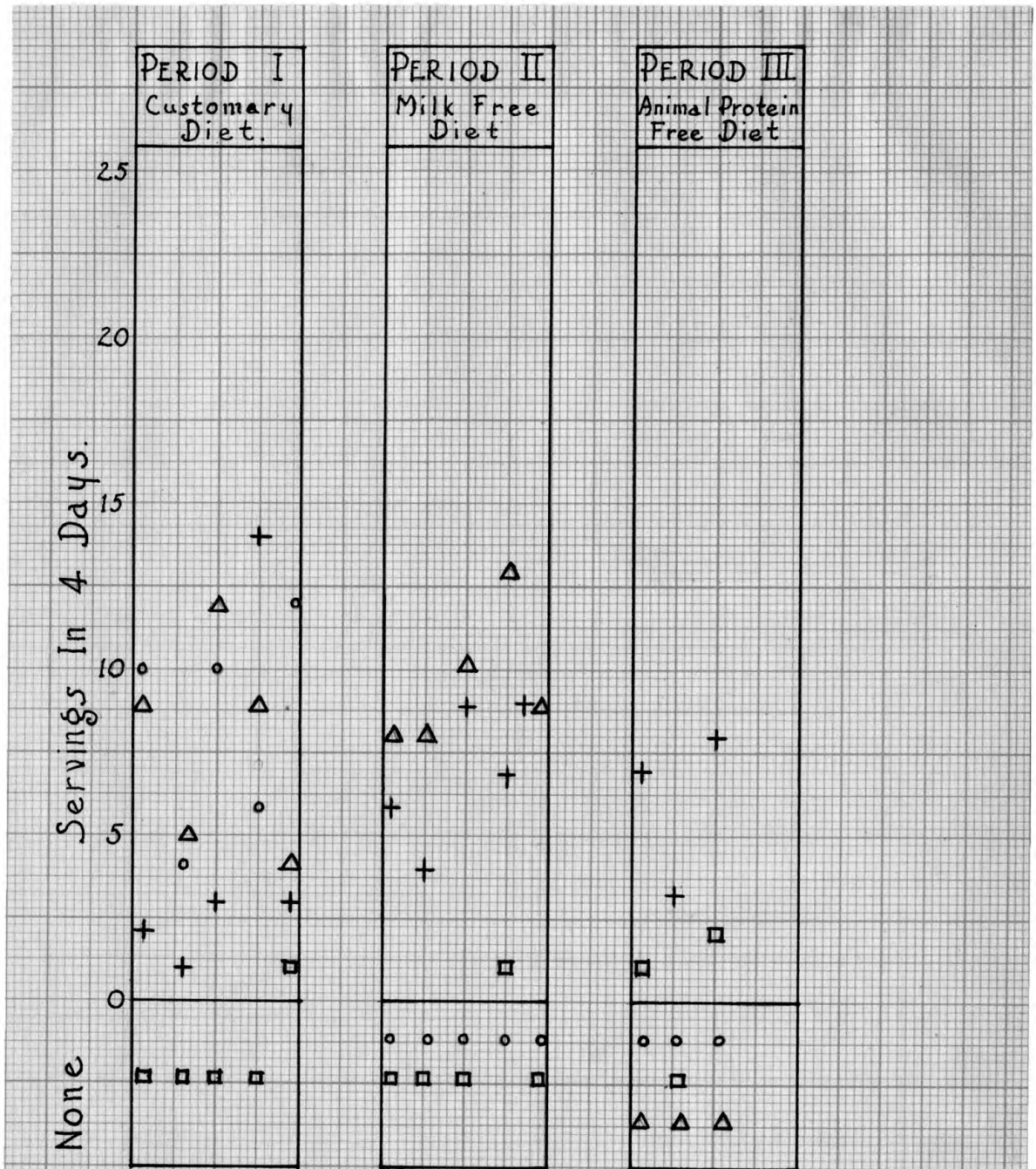


FIG. 5. (SERIES II)
Reported Servings of High Phosphorus Foods In 4 Days.

TABLE X

REPORTED SERVINGS OF HIGH PHOSPHORUS FOODS

Subjects Having Free Choice of Food

Series II

Amount of Phosphorus	No. of subjects	Average servings per subject: Milk & cheese	Dried legumes	Meat, fish poultry, eggs	Wh. grain products
Customary Diet					
Above Sherman Standard	2	8.0	0.0	10.5	8.5
Sherman Standard to Sherman Minimum	3	8.6	0.3	6.0	2.0
Below Sherman Minimum	0	0.0	0.0	0.0	0.0
Milk Free Diet					
Above Sherman Standard	1	0.0	1.0	13.0	7.0
Sherman Standard to Sherman Minimum	3	0.0	0.0	9.0	7.3
Below Sherman Standard	1	0.0	0.0	8.0	6.0
Protein Free Diet					
Above Sherman Standard	0	0.0	0.0	0.0	0.0
Sherman Standard to Sherman Minimum	1	0.0	0.0	0.0	3.0
Below Sherman Minimum	2	0.0	1.5	0.0	7.5

cases those showing the highest phosphorus output also reported the largest number of servings of foods with high phosphorus content. This is especially true for the different periods. Individual variations in the other direction can probably be accounted for through inaccuracies in the food records.

Table XI summarizes the findings of Series I and Series II together with those of Coons et al (2) in an experiment with a group of Oklahoma college women. While Series II used fewer subjects than Series I, these experiments indicate that there was little seasonal variation in the phosphorus intake of freely chosen diets of college women at Kansas State College of Agriculture and Applied Science. In each case the average figure was well above the Sherman (10) standard. The figures for the Oklahoma study were lower and fell below the Sherman standard but were above the requirement. Averages for the restricted diets decreased in proportion to the degree of restriction placed upon them.

SUMMARY AND CONCLUSIONS

This investigation is a study of the phosphorus intake of college women as indicated by the phosphorus output. For Series I, collections of urine and feces were made by 25 subjects over a 4-day period in the fall and again in

TABLE XI

PHOSPHORUS INTAKE OF GROUPS OF COLLEGE WOMEN
CALCULATED FOR A 70 KG. SUBJECT

	No. subjects	P intake
K. S. C.		
Series I - Fall	25	1.39
Series I - Winter	25	1.40
Series II - Summer (freely chosen diet)	5	1.40
Series II - " (milk free diet)	5	1.11
Series II - " (animal protein free diet)	3	0.82
Oklahoma		
Coons et al (2)	17	1.19

the winter. The subjects were asked to follow their customary eating habits during those periods but to keep a record of all the food consumed. Quantitative determinations were made of the phosphorus content of urine and feces. Figures were tabulated so that the total phosphorus output could be calculated for each subject per person per day and per 70 kilograms per day.

For Series II, five subjects were used in a similar way to study the effect of certain restrictions upon their diets. In the first period these subjects were asked to eat their usual diets, in the second period to omit milk and milk products, as ice cream and cheese, and during the third period to omit all high protein foods of animal origin.

The study shows that these groups of subjects were using an average of 1.40 grams of phosphorus per day per 70 kilograms when eating their regular diets. This figure is well above the standard of 1.32 grams given by Sherman. When eating their customary diets, none of the subjects studied showed a phosphorus output below the Sherman requirement of 0.88 gram per day per 70 kilograms.

Averages were similar for those eating freely chosen meals, as in a cafeteria, and those eating set meals, as in a boarding house or club. Averages for the fall and winter periods with 25 subjects and for the summer period with 5

subjects were similar, indicating little seasonal variation in phosphorus used when these subjects were eating their customary diets.

When the diet was restricted the phosphorus was decreased. This was noticeable when milk and milk products were excluded but became still more evident when all foods high in animal proteins were avoided. When the subjects did not receive foods high in animal protein their phosphorus fell below the standard and even below the requirement in some cases, a good indication of the value of foods high in animal protein as sources of phosphorus in the diet of the college woman.

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