



122
057
THS

POTASSIUM INTAKES AND
RETENTIONS OF COLLEGE AGE
WOMEN ON SELF-SELECTED DIETS

Thesis for the Degree of M. S.
MICHIGAN STATE COLLEGE
Joan Alison Plummer
1947

This is to certify that the

thesis entitled

"Potassium Intakes and Retentions
of College Age Women on Self-Selected Diets."

presented by

Joan Alison Plummer

has been accepted towards fulfillment
of the requirements for

M.S. degree in Foods and Nutrition

Margaret A. Ohlson
Major professor

Date August 29, 1947

THESIS

POTASSIUM INTAKES AND RETENTIONS
OF COLLEGE AGE WOMEN ON
SELF-SELECTED DIETS

by
JOAN ALISON PLUMMER

A THESIS

Submitted to the Graduate School of Michigan
State College of Agriculture and Applied
Science in partial fulfilment of the
requirements for the degree of

MASTER OF SCIENCE

Department of Foods and Nutrition

1947

The writer wishes to express
her appreciation to Dr. Margaret A. Ohlson for her
encouragement, suggestions, and guidance during
this study, to Dr. Dena C. Cederquist for her inter-
est and valuable assistance, and to all others who
in any way contributed to making this study possible.

TABLE OF CONTENTS

	Page
ROLE OF POTASSIUM IN THE BODY	1
LITERATURE	5
Studies of Potassium Metabolism Done on Children	5
Studies of Potassium Metabolism Done on Pregnant Women	10
Studies of Potassium Metabolism Done on Adults	12
Summary	17
EXPERIMENTAL PROCEDURE	19
Source of Material	19
METHODS	21
Development of Standard Curve	21
Ashing Procedure	23
Recovery Studies	23
RESULTS AND DISCUSSION	26
SUMMARY	37
LITERATURE CITED	38
APPENDIX	42

LIST OF TABLES

Table		Page
I	Potassium and Nitrogen Intakes and Retentions of Children as Reported in the Literature	8
II	Potassium and Nitrogen Intakes and Retentions of Pregnant Women as Reported in the Literature	11
III	Potassium and Nitrogen Intakes and Retentions of Normal Active Adults as Reported in the Literature	14
IV	Source of Material	20
V	Recoveries of Added Potassium from Ashed Samples of Food and Excreta	24
VI	Potassium Intakes of Thirteen College Women	27
VII	Potassium Intakes of College Women per Kilogram of Weight	28
VIII	Potassium Intakes and Retentions of Thirteen College Women	29

LIST OF FIGURES

Figure		Page
I	Standard Curve	22
II	Relation of Potassium Intake and Urinary Excretion	32
III	Relation of Potassium Intake and Retention	34
IV	Relation of Potassium and Nitrogen Retentions	35

ROLE OF POTASSIUM IN THE BODY

Although little is known about the role of potassium in the body, potassium has been found to be present in abundance in the living cell, while the tissue fluid is relatively poor in this element. (Fenn, 1940)

That potassium is important in both the function of the muscle and nervous tissue has been demonstrated many times. (loc. cit.) Although the exact mechanism by which it functions is not known, certain experimental facts can be stated. For instance, in isolated muscle, contraction of the muscle leads to a loss in potassium. Small amounts of potassium have been found to cause an increase in the response of the muscle. Likewise, small amounts of potassium cause stimulation of the nerve, while larger amounts depress its activity. Potassium is thought to function in the neuro-muscular transmission, in that application of potassium to certain nerves causes an excitation of the related muscle.

The relation between potassium and muscle function suggests that potassium may in some way be associated with carbohydrate metabolism. This relationship has been studied, and certain facts have been demonstrated, although some of the evidence is contradictory. Injections of glucose into the blood of cats and rats has been found to lower the blood potassium, suggesting that the sugar has been deposited in the tissues with potassium. Silvette et. al. (1938) have found that injecting potassium into cats and rats causes an increase in the blood sugar, and a lowering of liver and

muscle glycogen. In contrast to this, Odashima, as quoted by Fenn, found that the injection of potassium chloride lowered the blood sugar of rats. Certain German workers have found that injections of potassium chloride produced similar effects in man.

Further information regarding the metabolism of potassium has been gained by the use of the radioactive element. As far as it is known, there is no site of potassium storage in the body. Work done by Greenberg et. al. (1938), and by Fenn et. al. (1940) has shown that radioactive potassium is taken up readily by the tissues in exchange for potassium already present. Anderson et. al. (1939) found that rats on a diet poor in potassium retained more radioactive potassium than did normal rats.

Potassium deficiencies also have been studied in animals, and a few cases have been reported in man. As early as 1918, Osborne and Mendel produced potassium deficient rats, and later Miller (1933) described the same effects of slow growth and abnormal alertness in rats by feeding a diet low in potassium. In 1942, Follis fed rats a potassium deficient diet. Since a low potassium diet, adequate in everything else, is difficult to obtain, they discredited the work of the former workers on the basis of the fact that poor growth and other symptoms were the results of other deficiencies in the diet. On a diet containing 0.01 percent potassium, and adequate in everything else, these workers were able to produce cardiac and renal lesions in rats. Recently, Holler (1946) reported a case of diabetic acidosis,

in which a potassium deficiency developed following treatment for the disease. McCollum (1939) has suggested that a possible danger exists in using a low potassium diet in the treatment of Addison's disease.

That potassium is important in the body, is seen further in that potassium therapy has been successfully used in the treatment of such conditions as edema, allergy, and familial periodic paralysis. In 1932, Barker treated sixteen cases of edema with a diet low in sodium and high in potassium. All four cases lost their edema. In 1938, Bloom treated twenty-nine cases of hay fever with different potassium salts, and all showed relief of symptoms. Three cases of urticaria also improved when 0.32 grams of potassium chloride were given three times daily. In 1939, Rusk reported six cases of chronic urticaria which showed definite improvement on a low sodium, high potassium diet plus four to six grams of potassium chloride a day.

In 1937, Herrington et. al. successfully treated two cases of familial periodic paralysis with five grams of potassium citrate at each sign of an attack. Gammon, in 1938, studied the serum level of potassium in patients with this disease, and observed a definite lowering during an attack. By giving potassium chloride nightly, the development of seizures was prevented or at least made less frequent.

It has been assumed that potassium is supplied abundantly by natural foods. However, there is little evidence of the actual amounts of potassium taken into and retained by the body. McCollum (1939) suggests that the average potassium

intake should be 0.06 grams per kilogram of body weight. As far as is known there is little experimental evidence for this statement. Recent work done in this laboratory suggests that this amount may not be supplied by the average dietary. This point will be discussed later in the review of literature.

It is possible that the development of modern manufacturing processes has reduced the original mineral content of many of our so-called natural foods, and the assumption of an adequate potassium intake merits further study. It is therefore the purpose of this study to investigate the potassium intakes and retentions of healthy young women on self-selected diets, and to study any factors which may appear to influence the retention of the mineral. It was hoped that through a study of this sort, some information concerning the metabolism of potassium might be gained.

LITERATURE

A review of the literature reveals that, from time to time, attempts have been made to measure the potassium metabolism by means of a balance study. These studies have been confined chiefly to experiments done on children and pregnant women, where rapid growth is a predominant factor. Yet, because of our inadequate knowledge on this subject, and because of the possible influence of such factors as protein metabolism on the potassium retentions, these studies will be discussed here. There have been a few studies done on the normal adult, and these will also be included.

The earliest attempt to study potassium metabolism in this country was made by Benedict (1915) in his experiments on the fasting man. He studied only the potassium excretion, and reported that the average daily excretion for a period of thirty-one days was 0.875 grams when no food was taken.

The next step in the development of studies of potassium intake was the study of food records by Sherman in 1918, who calculated the daily potassium intake from 150 American dietaries. From this work, he states that the average daily potassium intake per 3000 calories is 5.39 grams.

Studies of Potassium Metabolism Done on Children.

The earliest work on potassium retentions of children was done by Sawyers et. al. (1918). They studied the mineral metabolism of two children, five and eight years of age, on a normal diet, and then on a high fat diet. The results of

this experiment can be seen in Table I. There is little difference between the potassium or the nitrogen intakes on either the normal or the high fat diet. On the normal diet, the potassium intake of both children was 1.267 grams per day, and both children could be considered in equilibrium with respect to potassium. The nitrogen intake on the normal diet was 12.6 grams per day, and while one child retained 0.615 grams per day, the other child was in equilibrium. There seemed to be no relation between the nitrogen and the potassium retentions. The high fat diet resulted in considerable losses in both potassium and nitrogen. In both children, the increase in the negative nitrogen balance, due to the high fat diet, was accompanied by an increased loss of potassium. The urinary excretions of both children increased slightly on the high fat diet from 1.176 to 1.420 and 1.049 to 1.237 grams per day respectively, while the potassium content of the feces remained unchanged.

In 1923, Shohl and Sato studied the mineral metabolism of two normal infants on a diet consisting chiefly of milk (Table I). The urinary potassium was higher for the child receiving the higher intake of potassium, while the potassium content of the feces was approximately the same for both children. The nitrogen and potassium retentions were similar in the two infants and any difference in retentions were probably related to the fact that the older infant was malnourished.

In 1932, Macy, in an extensive study of the metabolism of twenty-nine children ranging from four to twelve years of

age, made 519 observations over a period of 2,595 days. The results of this study can be found in Table I. She found the mean potassium intake of these children to be 2.776 grams per day, with a mean retention of 0.239 grams. The mean urinary excretion was 2.191 grams per day, and the mean fecal excretion 0.209 grams per day. Both the potassium intakes and retentions increased with the age of the child, as did the nitrogen intakes. The nitrogen retentions paralleled the nitrogen intakes, and also the potassium retentions until the end of the tenth year. During the eleventh and twelfth years, the nitrogen retentions decreased slightly, although the intakes remained the same. The potassium retentions at this time, however, continued to increase, although the potassium intake remained the same. It is possible that, while the growth of soft tissue is slowing up, the increase in physiological growth of certain glands during adolescence increases the demand for potassium. The urinary excretions of potassium increased with the intake, while the fecal excretions varied, and showed no relation to the intake.

In 1939, Souders et. al. studied the potassium metabolism of three children from four to six years of age, in connection with a study done on the influence of different types of milk on growth. The mean potassium intake on the untreated milk was 2.695 grams per day, with a mean retention of 0.175 grams per day. The results for the individual children can be seen in Table I. The mean nitrogen retention was 0.350 grams per day, and there was very little difference for the individual children. The retention of potassium by

TABLE I

POTASSIUM AND NITROGEN INTAKES AND RETENTIONS OF CHILDREN
AS REPORTED IN THE LITERATURE

Author	Age Yrs	Weight Kilo	Sex	Potassium Intake gm/day	Potassium Retention gm/day	Nitrogen Intake gm/day	Nitrogen Retention gm/day	Comments
Shohl et.al. (1923)	7mo	8.8	M	1.182	0.293	4.27	0.585	
	9mo	5.5	M	0.783	0.245	2.73	0.669	
Sawyers et.al. (1918)	5		M	1.261 1.207	-0.102 -0.476	12.6 11.93	0.615 -1.658	High fat diet
	8		M	1.261 1.207	-0.0017 -0.363	12.6 11.93	-0.035 -2.199	High fat diet
Macy et.al. (1932)	4			2.565	0.107	9.85	0.70	29 children studied
	5			2.574	0.187	9.74	0.61	
	6			2.629	0.203	10.17	0.46	
	8			2.955	0.252	11.56	0.62	
	9			3.252	0.292	13.06	1.05	
	10			3.560	0.263	13.04	1.03	
	11			3.487	0.284	13.27	0.81	
	12			3.487	0.346	13.27	0.81	
Senders et.al. (1939)	4½	16.9		2.692	0.152	9.802	0.514	Fluid milk diet
		17.2		2.623	0.189	9.563	0.814	Evap. " "
		18.5		2.760	0.302	10.06	0.834	Irrad. " "
	5	17.2		2.602	0.224	9.168	0.361	Fluid " "
		17.2		2.594	0.189	9.150	0.888	Evap. " "
		17.8		2.588	0.267	9.131	0.595	Irrad. " "
	5½	18.3		2.703	0.201	9.845	0.329	Fluid " "
		18.3		2.611	0.220	9.534	0.531	Evap. " "
		19.5		2.757	0.371	10.062	0.683	Irrad. " "
Hawks et.al. (1942)	3	14.5	F	3.002 2.857	0.188 0.159	6.844 9.164	0.450 0.522	Extra protein given as gelatin & egg white
	3	13.6	F	2.679 2.638	0.149 0.136	6.011 8.038	0.340 0.530	
	4	16.9	M	3.414 3.414	0.203 0.237	7.605 10.444	0.423 0.642	
	4½	18.6	M	3.460 4.073	0.186 0.223	9.542 12.890	0.707 1.153	
	4½	17.2	M	3.165 3.732	0.103 0.206	8.738 11.816	0.482 0.894	Extra protein given as milk

all the children was greater on the irradiated milk than it was on the untreated or evaporated milk, although the intake for all the children was lower than it had been previously. This increase in retention did not seem to be related in any way to the nitrogen intakes or retentions.

In 1942, Hawks et. al. studied the potassium balances of preschool children between the ages of three to four years, who were receiving medium and high protein diets (Table I). For the five children studied, the intakes of potassium on a diet supplying three grams of protein per kilogram ranged from 2.68 to 3.46 grams per day. The retentions ranged from 0.103 to 0.203 grams per day, while the daily urinary excretions ranged from 2.054 to 2.704 grams per day. The fecal excretions ranged from 0.447 to 0.595 grams per day, and were not related to the intake. On a diet containing four grams of protein per kilogram, the potassium intake ranged from 2.638 to 4.073 grams per day, and the retentions from 0.136 to 0.237 grams per day. When the retention is calculated on the basis of percentage intake, the range on the diet containing three grams of protein per kilogram was 3.2 to 6.1 percent, and that on the diet supplying four grams of protein per kilogram was 5.0 to 6.8 percent. This slightly higher range for the percentage of potassium retained, was due to an increase in retention made by one child on the higher protein intake. This subject, and also one other, received the extra protein in the form of milk. The other three subjects received the extra protein as egg white and gelatin. For these three subjects, there was no increase in

the potassium intake on the higher protein diet, whereas for the two children receiving their extra protein as milk, the potassium intake was increased.

Studies of Potassium Metabolism Done on Pregnant Women.

In 1934, Coons et. al. studied the potassium metabolism of five women between the 18th to 38th week of pregnancy on a self-selected diet. There were from four to six successive balance periods of four days in length carried out on each woman. The potassium intakes ranged from 2.30 to 4.47 grams per day with a mean intake of 3.64 grams per day. The mean potassium retention was 0.51 grams per day, while the mean daily urinary excretion was 2.698 grams. The mean fecal excretion was 0.424 grams.

Studies on individual women during pregnancy have been done by Hummel et. al. in two instances. In 1935, they studied the mineral metabolism of one woman from the 135th to the 280th day of pregnancy. During this period, twenty-eight successive balance periods of five days each were carried out. The mean intakes and retentions of both potassium and nitrogen can be found in Table II. The potassium intake ranged from 5.38 to 7.58 grams per day, and the retentions from 0.25 to 3.15 grams per day. The mean urinary excretion was 4.48 grams, and the mean fecal excretion 0.69 grams per day.

The second study done by Hummel et. al. (1936) was carried out on one woman during the last sixty-five days of pregnancy. There were thirteen successive balance periods

TABLE II
POTASSIUM AND NITROGEN INTAKES AND
RETENTIONS OF PREGNANT WOMEN AS REPORTED IN THE LITERATURE

Author	No.of Subjects	Age Years	Weight Kilo.	K Intake gm/day	K Retention gm/day	N Intake gm/day	N Retention gm/day
Coons et.al. (1934)	5	25	57.6	3.64	0.51	11.58	
Hummel et.al. (1935)	1	18	52-56.7	4.05	0.01	14.05	1.32
Hummel et.al. (1936)	1	30 $\frac{1}{2}$	61.4	6.60	1.40	19.01	3.06

of five days each. The subject was given an adequate diet in which the potassium intake was kept constant at 4.05 grams a day. The urinary excretions varied from 3.06 to 4.04 grams per day, while the fecal excretions ranged from 0.29 to 0.36 grams per day. The retentions ranged from -0.34 to +0.25 grams, but for the most part, the subject remained in equilibrium with an average daily retention of 0.01 grams.

Although these data on pregnant women are interesting, more work needs to be done before any statement regarding the potassium metabolism can be made.

Studies of Potassium Metabolism Done on Adults.

In the studies reviewed to date, the factor of growth is prominent and this undoubtedly influences the individuals' needs for potassium. Balance studies done on potassium intakes, in the normal adult, will be discussed next.

In 1923, Clarke studied the mineral metabolism of four prisoners over a period of eight months. During this time, different diets were fed; however, only the data on the self-selected diet will be discussed here. For each subject, four successive balance periods of seven days duration were carried out. The average daily potassium intake for the group during this period was 2.497 grams, and the average daily retention was 0.226 grams per day. The individual intakes and retentions for each period can be seen in Table II. The average daily urinary excretion for the group was 1.901

grams, while the mean fecal excretion was 0.409 grams per day. While the potassium and nitrogen intakes for the individual were fairly constant for the four balance periods, the retentions of both varied considerably from period to period for the individual. For subject #3, there were two periods in which the subject was in definite negative retention. This might be expected as the subject was an older man. There was one other subject who was in negative potassium balance for one out of the four periods studied. Nitrogen retentions varied even more for the individual than did the potassium retentions. They were all positive, and for the most part were high, indicating a previous protein deficiency. Although neither the potassium nor the nitrogen intakes had changed much for the eight weeks prior to the self-selected diet, the fact that all four subjects weighed between 57.7 and 67.7 kilograms would indicate malnutrition.

Wiley et. al. (1933) studied the mineral metabolism of a normal man, twenty-three years of age, in connection with an experiment done on inorganic salt balances during dehydration and recovery. For the first three day control period, the dietary intake of potassium was 2.114 grams, and the retention was -0.217 grams per day (Table III).

In 1939, Tompkins studied the potassium metabolism of two college age women on a self-selected diet. Food and excreta collections for two consecutive five day periods were made each month. Ten five day periods were studied for subject A over an interval of six months, and five periods for subject B over an interval of four months. The average

TABLE III
POTASSIUM AND NITROGEN INTAKES AND RETENTIONS
ON NORMAL ACTIVE ADULTS AS REPORTED IN THE LITERATURE

Author	Subject No.	Age Years	Weight Kilo.	K Intake gm/day	K Retention gm/day	N Intake gm/day	N Retention gm/day
Clarke (1923)	1-Male	22	62.3	2.990	-0.033	11.9	2.09
				2.621	0.287	11.2	0.35
				2.421	0.331	11.56	2.1
				2.374	0.279	11.26	2.0
	2-Male	31	67.7	3.073	0.239	12.97	3.17
				2.691	0.219	12.14	0.97
				2.290	0.773	10.5	2.75
	3-Male	49	57.7	2.687	-0.597	11.2	0.89
				2.230	-0.327	10.2	1.97
				2.051	0.414	10.4	2.69
				2.151	0.307	11.3	2.95
	4-Male	42	57.7	2.584	1.124	10.8	3.81
				2.353	0.059	10.2	1.84
				2.330	-0.03	9.87	2.34
				2.431	-0.246	10.09	1.41
	1-Male	23		2.114	-0.217		
Wiley et.al. (1933)	1-Male	23		2.114	-0.217		
	A-Female	21	51.8	3.182	0.552		
	B- "	18	65	2.516	-0.031		
	A- " *			3.111	0.576	9.985	2.37
Tompkins (1939)	B- " **			2.626	-0.025	10.67	0.315
	1-Male			2.	0.16		
	2- "			2.	-0.03		
	3- "			2.	0.34		
Green et.al. (1942)	1-Female	70		1.956	0.019	9.0	-0.2
	2- "			2.115	0.103	8.9	0.7
	2- "	57		2.912	0.149	11.4	0.4
	3- "	52		2.596	-0.199	7.0	0.1
This Laboratory (1946) ***				2.448	-0.307	6.5	-0.6
	4- "	over 50		3.735	-0.080	13.0	-0.6
				3.678	-0.201	13.6	0.5

*** Unpublished data courtesy of Dr. Cedarquist.

** Average potassium and nitrogen retentions for last four periods only.

* Average potassium and nitrogen retentions for first six periods only.

[illegible]

• 100 •

potassium intakes and retentions for these subjects can be found in Table III. Nitrogen figures are given for the first six periods for subject A, and for the last four periods for subject B. The potassium intakes and retentions for these periods only were averaged, and these are also shown in Table III. Subject A, who received more potassium, retained more than subject B who was in negative balance part of the time. Although the nitrogen intakes were approximately the same for each subject throughout the periods in which they were studied, the retentions for subject A were considerably greater than for subject B. Differences between the two subjects can be explained by the food habits for these girls. While subject A followed a good dietary pattern, subject B ate irregularly and from a diet which was inadequate in many respects.

There is little difference in the urinary excretion of the two subjects. The range for subject A was from 1.89 to 2.55 grams per day with a mean of 2.289 grams per day, while that of subject B varied from 1.850 to 2.752 with a daily average of 2.180 grams per day. The fecal excretions showed little variation from subject to subject, being 0.340 grams for subject A, and 0.367 grams for subject B.

In 1942, Greene et. al. studied the potassium balances of three normal men, in conjunction with a study done upon the electrolyte balance in persons with Addison's disease. The values reported here are those for the three day control period preceeding the experimental periods in which special treatment was given. Three to five days elapsed before each

series of experiments. These subjects received 2 grams of potassium a day, and the average daily retentions can be seen in Table III. When 6 grams of potassium, as potassium citrate, were given orally to two subjects, the retention increased from 0.86 to 1.64 grams per day and from 0.03 to 1.71 grams per day, respectively.

In 1945, Miller and Keys et. al. studied the effect of bed rest on the mineral and nitrogen retentions of six normal men. The experiment lasted for three to four weeks, and during this time the average daily protein intake fell from 75 grams to 55 grams. During bed rest, both the potassium and nitrogen retentions were negative. Although the most negative potassium balances were associated with the highest nitrogen loss, there was no constant relationship between them.

Recently, in this laboratory, * the potassium intakes and retentions of four older women on two five day periods of a self-selected diet have been studied. The results for the individual subjects can be found in Table III. The average daily potassium intake for the group was 2.794 grams, with a mean retention of -0.184 grams per day. The potassium intakes for each individual for the successive five day periods were within 0.1 grams, while the nitrogen intakes were within one gram. While two of the subjects were in equilibrium or in slightly positive retention for the two periods, the other two were in negative balance. Periods of positive

* Unpublished data - courtesy of Dr. Cederquist.

potassium retention were associated with positive nitrogen retentions, whereas in some instances, a period of negative potassium retention was associated with one of negative nitrogen retention, although the relationship here was not constant. The average urinary excretion was 2.354 grams per day, and it increased with increasing intakes. The average fecal excretion was 0.493 grams per day, and it varied from subject to subject and from period to period.

Summary.

Children between the ages of seven months and twelve years had daily potassium intakes of between 0.783 to 4.073 grams per day. The intake increased with age. Potassium retentions varied from -0.476 to 0.371 grams per day, and were influenced by age and intake. The urinary excretions reported ranged from 1.049 to 2.704 grams per day, and these paralleled the intake. Fecal excretions ranged from 0.209 to 0.595 grams per day. They were fairly constant for the individual and were unrelated to the intake. In pregnancy, it would be assumed that the need for potassium is greater than in the normal adult. However, due to the lack of experimental evidence, little can be said regarding the absolute amount needed.

The potassium intake of normal adults, on self-selected diets, ranged from 1.956 to 3.735 grams per day. The amounts of the intakes retained depended upon the dietary pattern, and upon the age of the individual. Of the five subjects

over forty-nine years of age, three were in negative potassium balance on a daily intake of 1.956 to 3.735 grams. Urinary excretions reported ranged from 1.950 to 2.752 grams, and paralleled the intake. Fecal excretions were between 0.340 to 0.490 grams per day.

The need for further study of potassium intakes and retentions of the normal individual can be seen. It appears that the percentage of intake retained depends upon both physiological and upon dietary factors.

The fact that potassium is lost in perspiration cannot be ignored. In the studies reviewed above, and in this study, no correction was made for this factor. In this study, all the collection periods were carried out during the cooler seasons of the year, so that excessive perspiration was avoided. Also conditions were fairly constant, and therefore the amount lost from day to day would not vary greatly. Freyberg et. al. (1937) studied the potassium losses due to insensible perspiration, and found the amount of potassium lost in twenty-four hours varied from 0.133 to 0.179 grams. Dill et. al. (1953) studied the potassium losses due to perspiration, and found that in a hot environment, the mean loss of two men over a period of twenty days was 0.078 grams per day. This value was obtained by calculation from the urinary output.

These losses due to perspiration are small in relation to intakes of from 2 to 3 grams of potassium a day.

EXPERIMENTAL PROCEDURE

Source of Material.

The work reported here was done as part of a series of larger studies on the nutritional status of college age women. The food and excreta to be analysed for potassium had been collected previously and stored as brown digests prepared by the method of Stearns (1929). Conditions under which they were collected can be found in Table IV.

In all cases, the method of collecting the samples was the same. All food eaten by each subject was weighed on a spring balance*, and an aliquot consisting of one-fifth of the amount of food consumed was weighed from the serving dish and collected in one flask containing hydrochloric acid. The solid food was separated from the liquid food purely as a matter of convenience. After each experimental period, the food was digested with hydrochloric acid, and made up to a known volume according to the method of Stearns. In the case of excreta, the feces for each period were collected and digested, as were aliquots of urine samples.

* Chatillon

TABLE IV
SOURCE OF MATERIAL

Worker	Subject No.	Diet	Weight	Digests Analyses
McKay * et.al. (1940)	7	Self-selected	Normal	Food and excreta for ten day balance period
Brown * et.al. (1946)	9 & 10	Self-selected	17 to 35 pounds over- weight	Food and excreta for seven day balance period
	8 & 11	Reduction		
This laboratory **	1 - 6 incl.	Self-selected	Normal	Food for two five day periods. Food and excreta for seven day balance period.

* Collections were made at Iowa State College and supplied through the courtesy of the nutrition laboratories of that school.

** Collections made at Michigan State College.

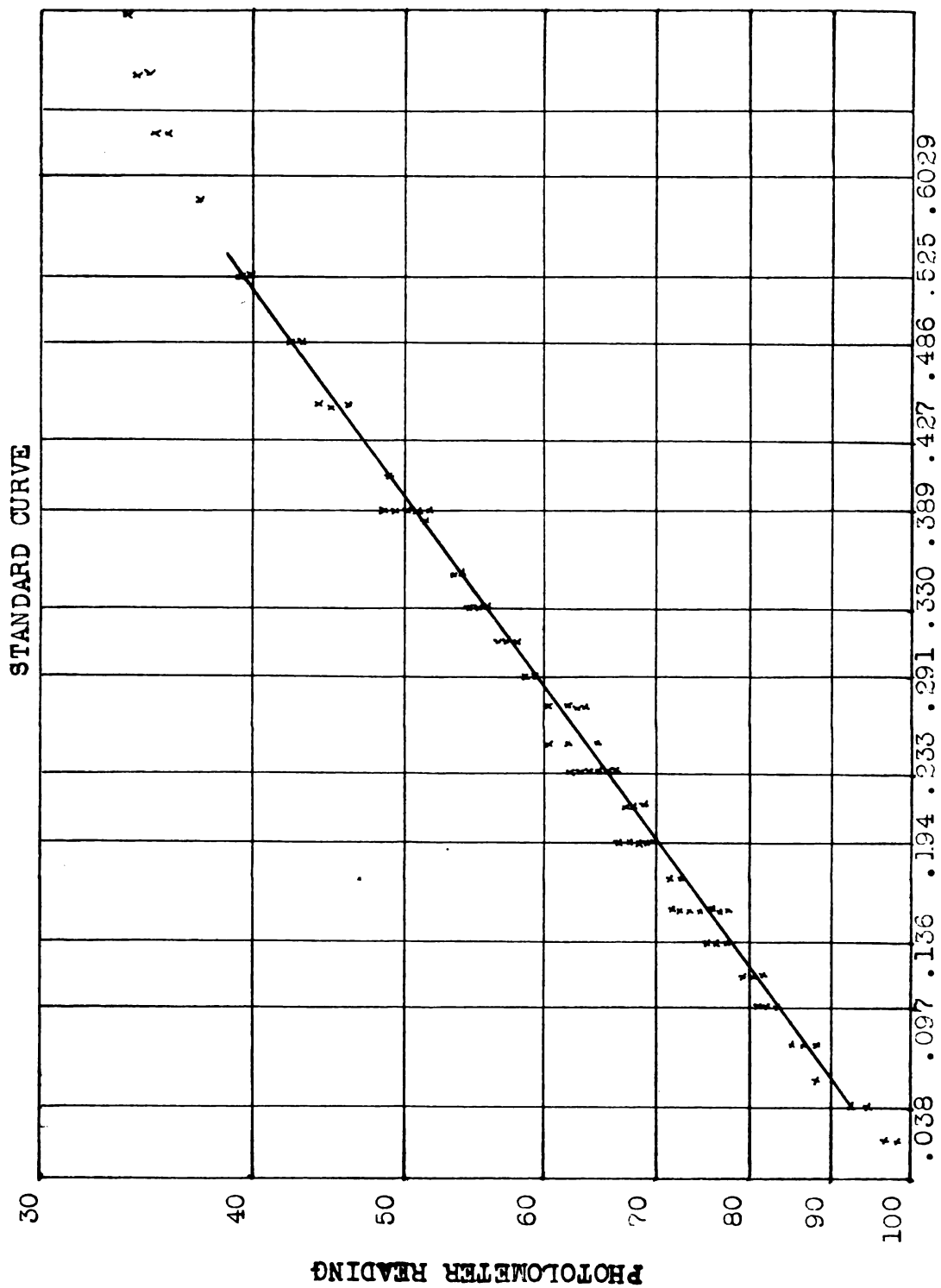
METHODS

Development of Standard Curve.

The procedure used throughout this study for potassium analysis was the Shohl and Bennett (1928) modification of the A. O. A. C. chloroplatinate method (1920).

Before any determinations could be done, it was necessary to develop a standard curve of potassium determinations carried out according to the method stated above.

A stock solution of KCL was made by dissolving 7.422 grams of pure KCL in 100 milliliters of water. From this, a standard solution was made which contained 10 milliliters of stock solution per 100 milliliters of standard solution. This gave a solution, one milliliter of which contained 0.389 grams of potassium. Solutions of potassium chloride containing from .02 to 3.2 milligrams of potassium per milliliter were then analysed for potassium. The usual precipitation and recovery procedures were carried out for each sample. Three different stock solutions of the same concentrations were made up, and each time the readings for the same concentration of sample checked within one photometer reading. By plotting all the concentrations of potassium used against the photometer readings obtained for each concentration, the standard curve shown in Figure 1 was drawn. From this curve, a chart was made giving the corresponding amount of potassium in milligrams per milliliter for each photometer reading (see appendix). All calculations are based on this chart.



MILLIGRAMS OF POTASSIUM

FIGURE I

Ashing Procedure.

In order to carry out analysis of the digests, samples of the digests were first ashed. These samples, to which ten drops of saturated sodium sulphate had been added, were first evaporated to dryness, then evaporated again with two milliliters of concentrated sulphuric acid. The ashing was done in a muffle furnace, which had been previously calibrated, at a temperature of 470°C for twenty-four hours. If a white ash was not obtained, a few drops of perchloric acid were added to the cooled ash, and the sample re-ashed for three to four hours starting with a cold furnace. The ash was then dissolved in water, and transferred quantitatively, to a 100 milliliter flask, and made to volume.

Recovery Studies.

Before proceeding with the analysis of the digests, the ashing procedure was checked. Because the solids were the most difficult to ash, a series of seven food samples were ashed in triplicate, and recoveries were done on each of these by adding 19.45 milligrams of potassium, as potassium chloride, to the third aliquot of each sample. The results of these recoveries are shown in Table V. They ranged from 90.64 to 108 percent.

The digests were ashed in groups of four. Duplicate ashings on each digest were carried out, and a recovery was done for each group of samples ashed. The ashed samples were made to volume and then analysed for potassium. The

TABLE V
RECOVERIES OF ADDED POTASSIUM FROM ASHED SAMPLES OF FOOD AND EXCRETA

Food %	Liquid %	Urine %	Feces %
108.0*	102.0	110.9	102.5*
103.4*	102.6	103.5	95.8
104.6*	95.1	111.2	98.0
99.0*	91.7		92.2
90.6*	95.8		88.0
103.4*	101.7		84.1
97.3			86.6
95.2			
94.7			
101.0			
107.8			
95.8			

* Done to check ashing techniques.

recoveries obtained throughout the entire study can be found in Table V. They ranged from 84.1 to 111.2 percent.

For each ashed sample, duplicate determinations were carried out. The ashed sample was first evaporated to dryness, then analysed for potassium by the method of Shohl and Bennett (1928). The alcohol used in the determinations was absolute ethyl alcohol, which had been previously distilled over soda lime. This alcohol was saturated with potassium chloroplatinate. Each time a set of potassium determinations was done, a blank containing a known amount of standard KCL was analysed. The mean recovery of these known samples done over the entire period was $102\% \pm 2.01$. The data presented here were obtained by averaging the determinations on duplicate samples of each digest. When calculated on a per day basis, all duplicates checked within 0.1 grams of potassium. If this was not the case, a determination was done on a third aliquot of that sample.

RESULTS AND DISCUSSION

The results are shown in Tables VI, VII and VIII.

Table VI gives the potassium intake as solid foods and as liquids for nine subjects on a self-selected diet, and for two subjects on a reduction diet. The potassium concentrations for solid foods and for liquids were separated, because it was of interest to study the proportion of the total potassium intake derived from vegetables and other solid foods, as compared to the amount coming from milk since the major source of potassium in the liquid digests was milk. The amount of potassium ingested as solid food for any one period for the subjects on the self-selected diet ranged from 1.481 to 2.692 grams per day. The amount of potassium taken as liquids ranged from 0.855 to 1.543 grams per day. The two subjects on the reduction diet were within this range of potassium intake from solid foods. The liquid digest provided subject 11 was with 1.957 grams of potassium a day and accounted for the total high intake. A high intake of potassium in the liquid digest parallels the amount of milk consumed..

Table VIII shows the potassium balances of the eleven subjects of this study, and of subjects A and B of the study done by Tompkins (1939). The total intakes of potassium ranged from 2.516 to 3.836 grams per day with the exception of one of the subjects on the reduction diet, whose daily intake was 4.129 grams. This, as mentioned above, was due to the large intake of potassium as milk.

TABLE VI
POTASSIUM INTAKES OF COLLEGE WOMEN

Subject	Periods	Food gm/day	Liquid gm/day	Mean Food gm/day	Mean Liquid gm/day
1	I	2.198	1.085	2.261	1.281
	II	2.155	1.352		
	III	2.431	1.405		
2	I	1.481	.964	1.657	1.057
	II	1.781	1.225		
	III	1.708	0.983		
3	I	2.584	1.196	2.261	1.321
	II	2.079	1.454		
	III	2.120	1.313		
4	I	2.177	1.130	1.951	1.067
	II	1.943	1.216		
	III	1.732	0.855		
5	I	1.840	1.191	1.951	1.315
	II	2.186	1.210		
	III	1.827	1.543		
6	I	1.613	1.116	1.772	1.100
	II	1.810	1.159		
	III	1.893	1.024		
7	I	2.563	0.988	2.563	0.988
8	I	2.648	1.146	2.648	1.146
9	I	2.692	0.999	2.692	0.999
10	I	2.463	1.096	2.463	1.096
11	I	2.262	1.957	2.262	1.957
A	Average n	1.956	1.226	.	
B		1.886	0.610		

TABLE VII
POTASSIUM INTAKES OF COLLEGE WOMEN PER KILOGRAM OF WEIGHT

Subject	Weight Kilo.	Intake gm/kilo.
1	50.5	0.076
2	60.7	0.045
3	64.3	0.055
4	62.5	0.048
5	64.6	0.051
6	64.2	0.045
7	57.7	0.062
8	70.9	0.054
9	75.01	0.049
10	62.3	0.057
11	74.5	0.057
A	51.8	0.061
B	65.0	0.039
Mean		0.048

TABLE VIII
POTASSIUM INTAKES AND RETENTIONS OF THIRTEEN COLLEGE WOMEN

Subject	Intake gm/day	Urine gm/day	Feces gm/day	Total Output gm/day	Retention gm/day
1	3.836	2.010	0.405	2.415	1.421
2	2.691	1.644	0.429	2.073	0.618
3	3.433	2.017	0.239	2.256	1.177
4	2.587	1.360	0.293	1.653	0.934
5	3.370	1.888	0.337	2.225	1.145
6	2.917	2.059	0.349	2.408	0.509
7	3.551	2.771	0.276	3.047	0.504
8	3.794	1.156	0.233	1.389	2.405
9	3.691	2.297	0.163	2.460	1.231
10	3.559	2.680	0.215	2.895	0.664
11	4.129	2.733	0.279	3.021	1.207
A	3.182	2.290	0.340	2.630	0.552
B	2.516	2.180	0.367	2.547	-0.0312

When the intakes are calculated on a per kilogram basis (Table VII), they range from 0.045 to 0.075 grams per kilogram. The one exception to this is subject B from Tompkins (1939) study, who received 0.039 grams a day. Of the other twelve subjects, there were only three who received 0.06 grams of potassium per kilogram. This is the figure suggested by McCollum (1939) as the standard potassium intake of the normal adult.

When considering potassium intakes, it is of interest to discuss the sources of potassium in the diet. It has generally been accepted that most of our potassium needs are supplied by vegetable foods, yet milk also contributes a considerable amount of potassium to the daily intake. It is for this reason that a discussion of the proportion of the potassium taken as milk in relation to the intake per kilogram is in order here. Twenty-three percent of the subjects had intakes of 0.045 grams per kilogram or less. These were subjects 2, 6 and B, and the percentage of potassium that they received in milk was 37, 35, and 24 percent respectively. Fifty-three percent of the group had intakes between 0.045 and 0.06 grams per kilogram. Of these, subjects 3, 5 and 11 received 38, 45 and 47 percent of their potassium as milk. The other three subjects, 4, 9, and 8 received 35, 26 and 30 percent respectively of their total potassium as milk. Of the twenty-three percent of the group that received more than 0.06 grams per kilogram (subjects 1, 7, and A), the proportion of the potassium received from milk was 37, 28 and 61 percent respectively. All this points to the fact that milk plays an

important part in supplying the potassium needs of this age group.

The urinary excretions ranged from 1.156 to 2.733 grams per day. That the urinary excretion of potassium tends to follow the intake is shown in Figure II. Subject 8, who was one of the subjects on the reduction diet, showed the greatest difference from the group response and was the subject who had the lowest urinary excretion. She is also the one who had the highest retention of potassium.

The fecal excretions ranged from 0.163 to 0.429 grams per day. They varied with the individual, and there was no relation to the intake. Although the weights of the stools were not obtained, the stools for subjects 8 to 11 inclusive were drier and smaller than those of the subjects of normal weight. The potassium content of the feces for subjects 8 to 11 were 0.163 to 0.279 grams per day, while the potassium content of the feces for the remaining subjects ranged from 0.239 to 0.429 grams per day. Since the potassium intake bore no relation to the potassium content of the feces, it is probable that the overweight subjects absorbed a greater proportion of the potassium. The possible greater economy in absorption of nutrients by obese subjects is seen from nitrogen and calcium studies done on obese young women (Brown et. al., 1946).

The range in the amount of potassium retained is wide, varying from -0.031 to 2.405 grams per day. There was only one subject in negative balance and this was subject B of

RELATION OF POTASSIUM INTAKE AND URINARY EXCRETION

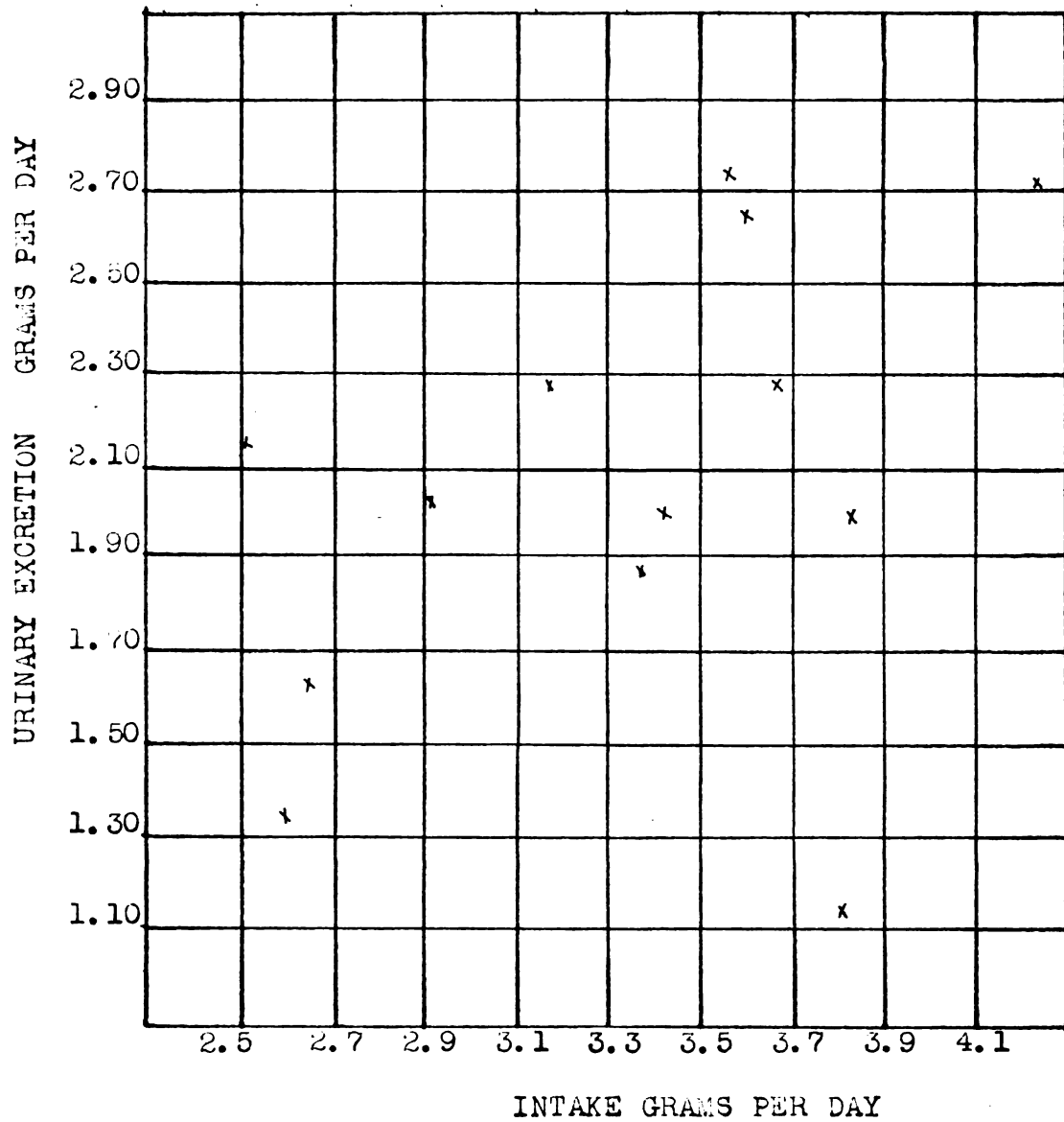


FIGURE II

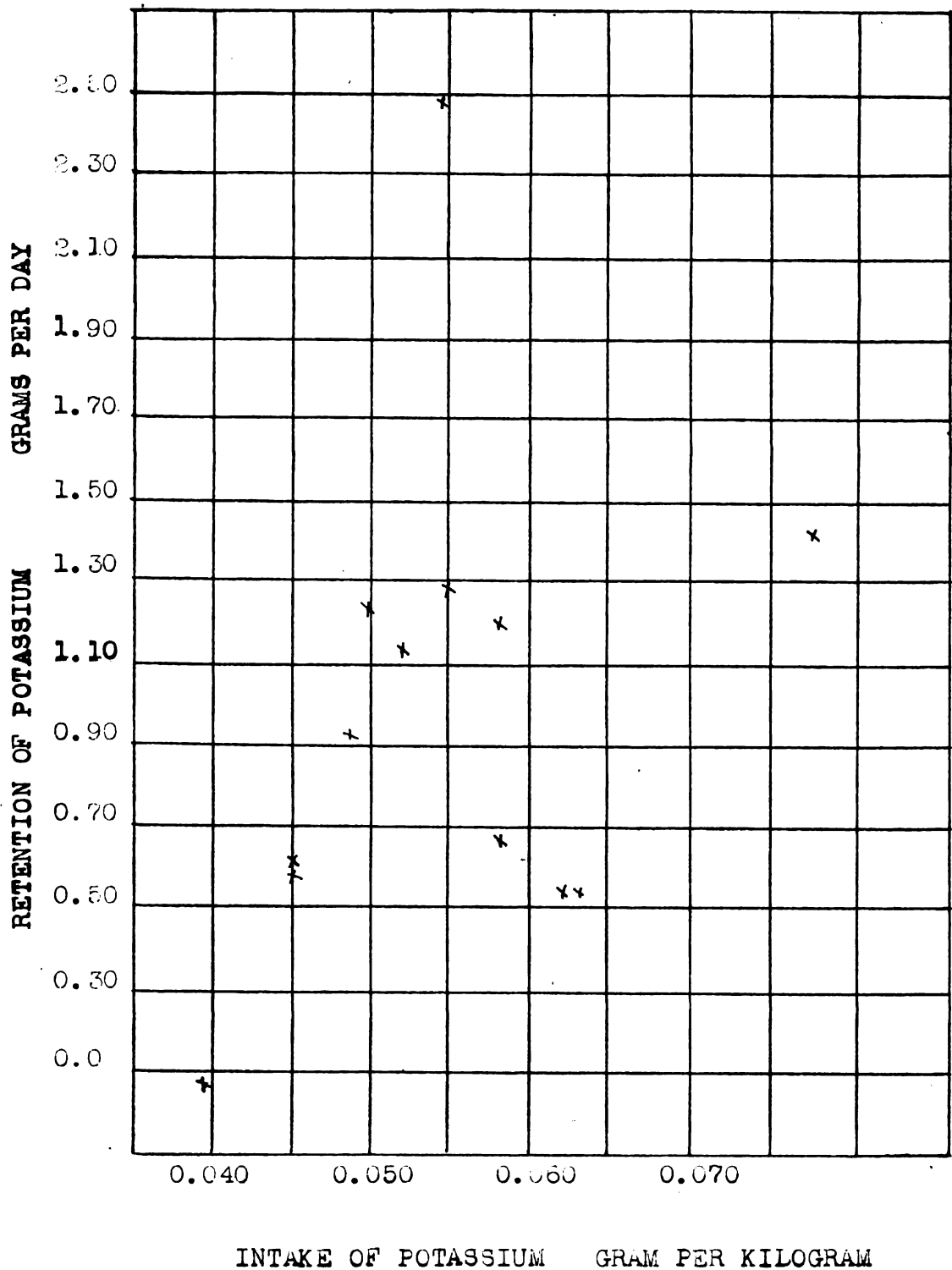
Tompkins' study (1939). All the subjects in this study were in positive balance, and the lowest retention obtained was 0.504 grams of potassium per day. Since eight of the eleven subjects studied here had potassium intakes of three or more grams per day, six of these retained more than 1.1 grams per day. While subjects 7 and 10 received three or more grams of potassium, they retained only 0.504 and 0.664 grams per day. The relationship between the potassium intake and retention can be seen in Figure III. There is a tendency for an increase in intake to cause an increase in retention. Again subject 8 shows the greatest difference from the group response with a retention of 2.405 on an intake of 0.052 grams per kilogram.

Because studies of nitrogen retentions of this age group give evidence for slow growth of soft tissue (McKay et. al.), it is of interest to study the relationship of nitrogen and potassium retentions (Figure IV). When the potassium retentions were plotted against the nitrogen retentions, the potassium retention increased as the nitrogen retention increased in the lower limits of nitrogen retention. However, when the nitrogen retention rises above 2.25 grams or more, this relationship no longer appears to be true.

The potassium intakes of all the subjects, with the exception of subject B (Tompkins' study), were sufficient to maintain a positive potassium balance. When Figure III is studied, it can be seen that an intake of 0.04 to 0.065 grams per kilogram resulted in retentions of 0.5 to 1.0 grams per day. This corresponds to an intake of 2.5 to 3.3

RELATION OF POTASSIUM INTAKES AND RETENTIONS

FIGURE III



RELATION OF POTASSIUM AND NITROGEN RETENTIONS

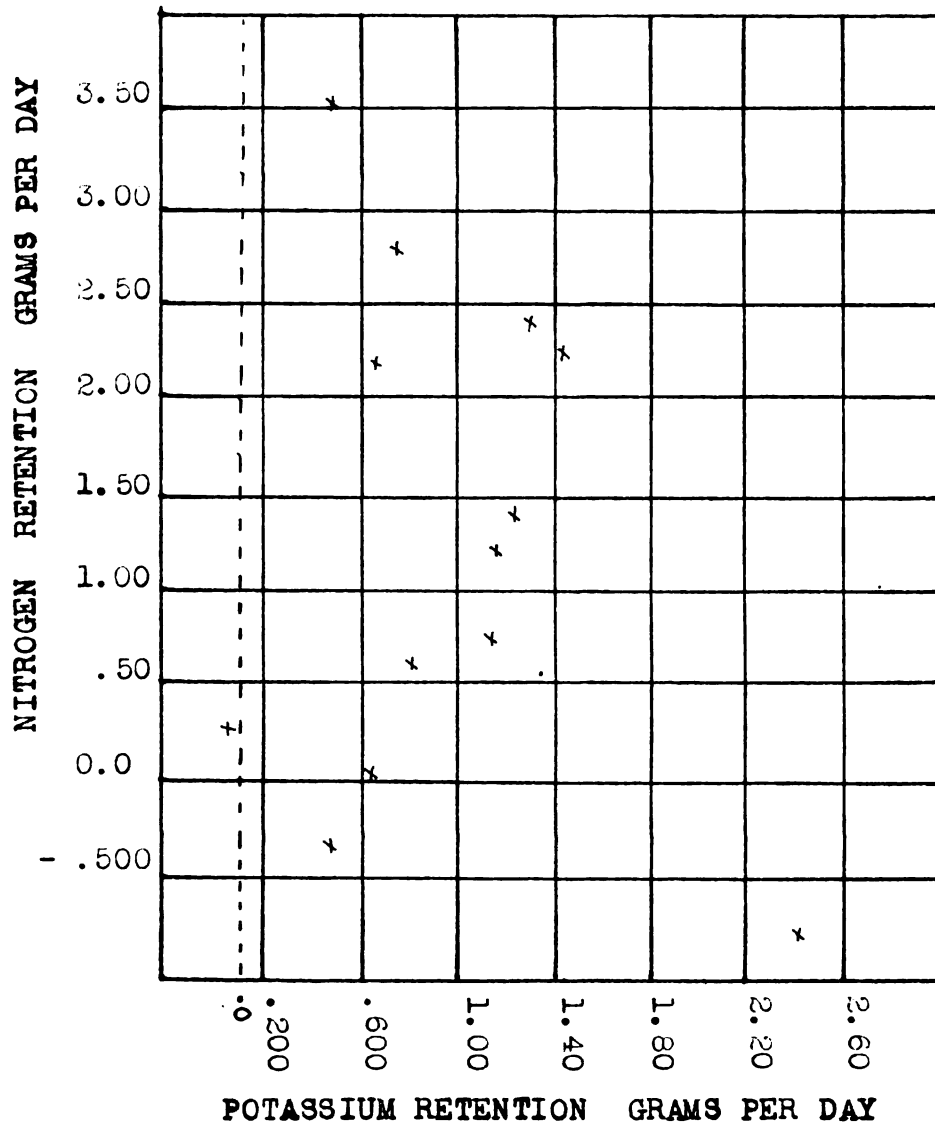


FIGURE IV

grams per day. Since the mean intake for the group was 0.048 grams per kilogram, and all of the subjects, except subject B, retained 0.5 or more grams of potassium daily, an intake of 0.048 grams per kilogram would seem to be a generous dietary allowance for this age group of women. This suggests that McCollum's figure of 0.06 grams per kilogram is higher than is needed. Of the thirteen subjects studied, only three ingested more than 0.06 grams of potassium per day, and for these subjects, the retentions varied from 0.576 to 2.405 grams per day. Six of the subjects receiving more than 3.3 grams of potassium per day stored the extra potassium in amounts above one gram per day.

Since these studies were not planned originally for potassium, and since all the intakes and retentions are high, the data is difficult to interpret. If equilibrium is adequate for this age group, then we can consider an intake of 0.048 grams per kilogram as a generous amount. On the other hand, this age group does show evidence of growth (McKay, 1940), and since some of the subjects here showed a capacity for storing potassium, it may be a question of how much retention the intake should allow for.

SUMMARY

The potassium intakes and retentions of college age women on self-selected diets have been studied. The data from two women on a reduction diet have been included also.

The potassium intakes ranged from 2.516 to 4.129 grams per day. When the intake was based on a per kilogram basis, the mean potassium intake was 0.048 grams per kilogram with a range of 0.039 to 0.075 grams per kilogram. All the subjects except one were retaining potassium. The mean retention was 0.949 grams per day.

The urinary excretions of potassium ranged from 1.360 to 2.773 grams per day, and increased with increasing intakes.

The fecal excretions ranged from 0.163 to 0.429 grams per day, and were not related to the intake.

The potassium retentions were studied with relation to the potassium intake. They were found to increase as the intake increased. When the potassium retentions were studied, with relation to the nitrogen retentions, they increased as the nitrogen retentions increased, except in the upper ranges of nitrogen retention.

It is concluded from this study, that the intake of 0.06 grams of potassium per kilogram suggested by McCollum, is more than is needed by college age women for retention. The mean intake of 0.048 grams per kilogram appeared to be enough to meet the needs of this group of well nourished young women, and to provide for a limited amount of storage.

LITERATURE CITED

- Anderson, E. M., and M. Joseph 1939 Electrolyte excretion studies in rats maintained on low sodium and high potassium diets. Proc. Soc. Exp. Biol. and Med., vol. 40, p. 344.
- Association of Official Agricultural Chemists 1920 Official and tentative methods of analysis of the Association.
- Barker, H. M. 1932 Edema as influenced by a low ratio of sodium to potassium intake. J. Amer. Med. Assn., vol. 98, p. 2193.
- Benedict, F. G. 1915 A study of prolonged fasting. Carnegie Institute of Washington, Publication No. 203, p. 289.
- Bloom, B. 1938 The use of potassium salts in hay fever. J. Amer. Med. Assn., vol. 111, p. 2281.
- Brown, E. G., Herman, C., and M. A. Ohlson 1946 Weight reduction of obese women of college age. II Nitrogen, calcium, and phosphorus retentions of young women during weight reduction. J. Am. Diet. Assn., vol. 22, p. 858.
- Brown, E. G., and M. A. Ohlson 1946 Weight reduction of obese women of college age. I. Clinical results and basal metabolism. J. Am. Diet. Assn., vol. 22, p. 849.
- Clarke, G. W. 1923 Studies in mineral metabolism of adult men. University of California Publications in Physiology, vol. 5, p. 195.
- Coons, C. A., Coons, R. R., and A. T. Schiebelbusch. 1934 The acid-base balance of the minerals retained during human pregnancy. J. Biol. Chem., vol. 104, p. 757.
- Dill, D. B., Jones, B. F., Edwards, H. T., and S. A. Oberg 1933 Salt economy in extreme dry heat. J. Biol. Chem., vol. 100, p. 755.
- Fenn, W. O. 1940 The role of potassium in physiological processes. Physiol. Rev., vol. 20, p. 377.
- Fenn, W. O., Noonan, T. R., Mullins, L. J., and L. Haege 1941 The exchange of radioactive potassium with body potassium. Am. J. Physiol., vol. 135, p. 149.

- Follis, R. H., Orent-Keilles, E., and E. V. McCollum 1942 The production of cardiac and renal lesions in rats by a diet extremely deficient in potassium.
- Freyberg, R. H., White, F. R., and F. D. Lathrop 1938 A study of the Na, K, Cl and water exchange in relation to nephritic edema. J. Clin. Invest., vol. 17, p. 515.
- Gammon, G. D. 1938 Relation of potassium to periodic family paralysis. Proc. Soc. Exp. Biol. and Med., vol. 38, p. 922.
- Greene, J. A., David, A., and G. A. Johnston 1942 Effect of adrenal cortical extract, desoxycorticosterone, and added potassium upon the electrolytic balance in normals and in Addison's disease. J. Clin. Endocrin., vol. 2, p. 49.
- Greenberg, D. M., Joseph, M., Cohn, W. E., and E. V. Tufts 1938 Studies in the metabolism of the animal body by means of its artificial radioactive isotope. Science, vol. 87, p. 438.
- Hawks, J. E., Bray, M. M., Hart, S., Whitmore, M. B., and M. Dye 1942 Potassium sodium and chloride balances of pre-school children receiving medium and high protein diets. J. Nutrition, vol. 24, p. 437.
- Herrington, M. S., and M. C. Durham 1939 Successful treatment of two cases of familial periodic paralysis with potassium citrate. J. Am. Med. Assn., vol. 108, p. 1339.
- Holler, J. W. 1946 Potassium deficiency occurring during the treatment of diabetic acidosis. J. Am. Med. Assn., vol. 131, p. 1186.
- Hummel, S. C., Sternberg, H. R., Hunscher, H. A., and I. G. Macy 1936 Metabolism of women during the reproductive cycle. J. Nutrition, vol. 11, p. 235.
- Hummel, F. G., Macy, I. C., and J. A. Johnston 1937 A consideration of the metabolism of women during a pregnancy. J. Nutrition, vol. 13, p. 236.
- Macy, I. C. 1942 Nutritional and Chemical Growth in Childhood, vol. 1, Evaluation. Charles C. Thomas, Publisher, Springfield, Illinois.
- McCollum, E. V., E. Orent-Keilles, and H. G. Day 1939 The Newer Knowledge of Nutrition. The Macmillan Co., New York, 5th ed., p. 208.

- McKay, H., Patton, M. B., Ohlson, M. A., Pittman, M. S., Leverton, R. M., Marsh, A. G., Stearns, G., and G. Cox 1942 Calcium, phosphorous, and nitrogen metabolism of young college women. J. Nutrition, vol. 24, p. 367.
- Miller, E. V., Michelson, O. B., Benton, W. W., and A. Keys 1945 The effect of bed rest on mineral and nitrogen balances. Federation Proc., vol. 4, p. 99.
- Miller, H. G. 1923 Potassium in animal nutrition. J. Biol. Chem., vol. 55, p. 45.
- Osborne, T. B., and L. B. Mendel 1918 The inorganic elements in nutrition. J. Biol. Chem., vol. 34, p. 131.
- Odashima, G. 1932 Tohoku J. Exper. Med., vol. 18, p. 250. Original not seen. Cited in Fenn (1940), p. 397.
- Rusk, H. A., Weichselbaum, T. E., and M. Somogi 1939 Changes in serum potassium in certain allergic states J. Am. Med. Assn., vol. 112, p. 2395.
- Sawyer, M., Baumann, L., and F. Stevens 1918 Studies of acid production. The mineral losses during acidosis. J. Biol. Chem., vol. 103, p. 33.
- Sherman, H. C. 1941 Chemistry of Foods and Nutrition. The Macmillan Co., New York, 6th ed., p. 223.
- Shohl, A. T., and H. Bennett 1928 A micro-method for the determination of potassium as iodooplatinate. J. Biol. Chem., vol. 78, p. 643.
- Shohl, A. T., and A. Sato 1923 Acid-base metabolism. II Mineral Metabolism. J. Biol. Chem., vol. 58, p. 257.
- Silvette, H., Britton, S. W., and R. Kline 1938 Carbohydrate changes in various animals following potassium administration. J. Physiol., vol. 122, p. 524.
- Souders, H. J., Hunscher, H. A., Hummel, F. C., and I. C. Macy 1939 Influence of fluid and evaporated milk on the mineral and nitrogen metabolism of growing children. Am. J. Dis. Child., vol. 58, p. 529.
- Stearns, G. 1929 A rapid method for the preparation of fecal digests suitable for use in nitrogen and mineral analysis. J. Lab. Clin. Med., vol. 14, p. 954.

- Tompkins, M. D. 1939 Nutritional status of Iowa State College women. V. Potassium balance studies on two students ingesting self-chosen diets. M. S. thesis, Iowa State College.
- Wiley, F. N. and L. L. Wiley 1933 The inorganic salt balance during dehydration and recovery. J. Biol. Chem., vol. 101, p. 83.

A P P E N D I X

CHART SHOWING CORRESPONDING AMOUNTS OF POTASSIUM
FOR EACH PHOTOLOMETER READING

Read- ing	Amt. K mg/ml	Read- ing	Amt. K mg/ml	Read- ing	Amt. K mg/ml	Read- ing	Amt. K mg/ml	Read- ing	Amt. K mg/ml
85.75	.0752	76.75	.1411	67.75	.2115	58.75	.2942	49.75	.3914
85.50	.0778	76.50	.1423	67.50	.2140	58.50	.2967	49.50	.3939
85.25	.0802	76.25	.1435	67.25	.2164	58.25	.2991	49.25	.3963
85.00	.0827	76.00	.1459	67.00	.2189	58.00	.3003	49.00	.3987
84.75	.0839	75.75	.1483	66.75	.2213	57.75	.3039	48.75	.4011
84.50	.0851	75.50	.1508	66.50	.2237	57.50	.3064	48.50	.4048
84.25	.0873	75.25	.1520	66.25	.2261	57.25	.3088	48.25	.4072
84.00	.0897	75.00	.1532	66.00	.2273	57.00	.3112	48.00	.4109
83.75	.0909	74.75	.1556	65.75	.2298	56.75	.3136	47.75	.4134
83.50	.0922	74.50	.1580	65.50	.2323	56.50	.3161	47.50	.4158
83.25	.0964	74.25	.1592	65.25	.2334	56.25	.3185	47.25	.4206
83.00	.0958	74.00	.1605	65.00	.2370	56.00	.3221	47.00	.4231
82.75	.0997	73.75	.1629	64.75	.2383	55.75	.3245	46.75	.4255
82.50	.1022	73.50	.1652	64.50	.2395	55.50	.3258	46.50	.4291
82.25	.1034	73.25	.1676	64.25	.2431	55.25	.3282	46.25	.4328
82.00	.1046	73.00	.1701	64.00	.2455	55.00	.3331	46.00	.4352
81.75	.1058	72.75	.1713	63.75	.2467	54.75	.3343	45.75	.4400
81.50	.1067	72.50	.1725	63.50	.2492	54.50	.3368	45.50	.4425
81.25	.1079	72.25	.1750	63.25	.2504	54.25	.3404	45.25	.4449
81.00	.1091	72.00	.1774	63.00	.2541	54.00	.3428	45.00	.4474
80.75	.1103	71.75	.1799	62.75	.2553	53.75	.3440	44.75	.4523
80.50	.1116	71.50	.1823	62.50	.2590	53.50	.3445	44.50	.4535
80.25	.1140	71.25	.1834	62.25	.2602	53.25	.3501	44.25	.4571
80.00	.1167	71.00	.1849	62.00	.2626	53.00	.3537	44.00	.4607
79.75	.1191	70.75	.1861	61.75	.2650	52.75	.3662	43.75	.4644
79.50	.1216	70.50	.1886	61.50	.2675	52.50	.3598	43.50	.4668
79.25	.1228	70.25	.1910	61.25	.2699	52.25	.3622	43.25	.4704
79.00	.1240	70.00	.1945	61.00	.2723	52.00	.3647	43.00	.4741
78.75	.1261	69.75	.1969	60.75	.2747	51.75	.3671	42.75	.4765
78.50	.1285	69.50	.1994	60.50	.2772	51.50	.3708	42.50	.4814
78.25	.1297	69.25	.2006	60.25	.2796	51.25	.3732	42.25	.4838
78.00	.1310	69.00	.2018	60.00	.2820	51.00	.3757	42.00	.4863
77.75	.1334	68.75	.2042	59.75	.2844	50.75	.3793	41.75	
77.50	.1362	68.50	.2066	59.50	.2869	50.50	.3829	41.50	
77.25	.1374	68.25	.2091	59.25	.2893	50.25	.3842	41.25	
77.00	.1386	68.00	.2103	59.00	.2918	50.00	.3866	41.00	

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

Mar 3 '48

82

ROOM USE ONLY

ROOM USE ONLY

MICHIGAN STATE UNIVERSITY LIBRARIES



3 1293 03175 4835