AN ABSTRACT OF THE THESIS OF

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Title: The Ascorbic Acid Requirements of Older Adolescents

Abstract Approved Redacted for privacy
(Major Professor)

The concentration of ascorbic acid in the plasma was determined on four levels of ascorbic acid intake for seven day periods in 1946-47 and on three levels of ascorbic acid intake for ten day periods in 1947-48. The subjects, eight girls and eight boys, were 16 to 19 year old freshman students at Oregon State College. All of the food eaten by the subjects during the experimental periods was weighed and the quantities were recorded. The reduced ascorbic acid in the foods was determined after each meal by the method of Loeffler and Ponting (1942) and daily fasting plasma ascorbic acid values were determined by the micro-method of Farmer and Abt (1936). The data in this study were analyzed statistically by testing the significance of the differences between the means and by analysis of variance.

The recommended allowance of the National Research Council (1945) for these subjects (80 mg for the girls and 100 mg for the boys) did not maintain mean plasma values as high as their respective means during the saturation period when they were receiving 200 mg of crystalline ascorbic acid in addition to the ascorbic acid from their food. On the recommended allowance all the mean plasma values for the girls were above 0.80 mg per cent, ranging from 0.83 to 1.07. The boys values ranged from 0.67 to 0.91 mg per cent; two out of seven values were below 0.80 mg per cent (data for one boy were excluded due to illness). A decrease in ascorbic acid intake to 10 mg less than the recommended allowance of the National Research Council made a statistically significant decrease in the plasma ascorbic acid concentration for only two of the eight girls and for one of the seven boys.

The plasma ascorbic acid concentrations of these subjects showed individual variation even when the ascorbic acid intake was considered on the basis of mg of ascorbic acid per kg of body weight.

The ten day experimental periods were more desirable than the periods of one week. This was particularly true for the saturation period when some of the subjects had been on diets low in ascorbic acid prior to the study.

THE ASCORBIC ACID REQUIREMENTS OF OLDER ADOLESCENTS

by

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CHAPTER I

REVIEW OF LITERATURE

A review of literature in the field of ascorbic acid requirements showed few data on adolescent subjects. The recommended allowances for ascorbic acid were derived from studies with adults, children 8 to 12 years, preschool children and infants (National Research Council, 1945). The allowances for children over 12 years apparently were not based on experimental studies with subjects of this particular age group.

Investigators have used various approaches to the problem of determining the ascorbic acid requirement of man. Some of the studies are based on the concentration of ascorbic acid in plasma or serum, others on urinary excretion levels and still others are a combination and comparison of both plasma or serum and urinary ascorbic acid. In order to study requirements, the daily intake of ascorbic acid must be known. Studies in which the intake is controlled and the food is weighed, sampled and analyzed for ascorbic acid are most accurate but in some studies food intake records have been kept and the vitamin content calculated using tables of nutritive value.

Experiments with Adults:

Belser, Hauck and Storvick (1939) comparing plasma and urinary ascorbic acid for seven adults found that two of their subjects required from 70 to 85 mg of ascorbic acid per day to maintain tissue saturation, three required from 85 to 100 mg and two required more

than 100 mg. This was a range from about 1.0 to 1.6 mg per kg per day.

Storvick and Hauck (1942) found a range from 1.07 to 1.58 mg per cent in the plasma values of six adults during saturation. Intakes of 65 to 150 mg of ascorbic acid plus 10 mg in the diet were required to maintain tissue saturation. These figures were established from data collected by daily determinations of urinary excretion and fasting plasma ascorbic acid. A definite correlation was observed between the daily urinary excretion of ascorbic acid and the concentration of ascorbic acid in the plasma on intakes of 75 mg or less but no consistently significant correlation was found between the two variables at intakes above 75 mg.

Ralli, Friedman and Sherry (1939) studying daily urinary excretion of ascorbic acid and occasional plasma ascorbic acid concentrations of three adults found 100 mg of ascorbic acid the optimum daily intake as reflected by maximum retention and low excretion. They believed the plasma ascorbic acid concentration was a more accurate index of vitamin C nutrition when the intake was below 100 mg daily, but response to intakes higher than 100 mg daily were shown more accurately by urinary excretion. They suggested that plasma ascorbic acid values of 1.0 mg per cent or higher indicated "complete" saturation of the tissues by vitamin C.

Three adult subjects studied by Todhunter and Robbins (1940) required 1.6 to 1.7 mg per kg per day to maintain the tissues in a state of saturation as indicated by the ascorbic acid in urine and

plasma. A total daily intake of 60 mg of ascorbic acid resulted in plasma ascorbic acid values above 1.0 mg per cent. A daily ingestion of more than 120 mg of ascorbic acid was required to raise the blood plasma to 1.4 mg per cent.

Fincke and Landquist (1942) studied the ascorbic acid intakes required to maintain plasma values of 0.8 mg per cent or above and also to maintain saturation. Daily intakes of approximately 1.1 and 0.8 mg of ascorbic acid per kg per day were necessary for the two women to maintain an average plasma ascorbic acid concentration of 0.8 mg per cent, and 1.1 and 1.2 mg of ascorbic acid per kg of body weight were required by the two men. Three other subjects needed 1.7, 1.8 and 2.0 mg per kg of body weight per day in order to maintain tissue saturation.

Kline and Eheart (1944) measured the variation among nine women in the amount of ascorbic acid necessary for saturation as indicated by urinary response to a 400 mg test dose. The subjects were considered saturated if 50 per cent or more of the test dose was excreted in 24 hours. Six of the women required 1.4 to 1.8 mg per kg, one required 0.6 mg or less per kg and the other two required 2.2 mg or more of ascorbic acid per kg of body weight.

The twelve subjects of Dodds and MacLeod (1944) were studied at four levels of ascorbic acid intake for periods of two weeks at each level. With an intake of 32-35 mg of ascorbic acid, their plasma ascorbic acid concentrations were decreased or barely maintained. The 57-60 mg intake during the following period brought about an

increase in the plasma value, and with the 82-85 mg intake a further increase in plasma ascorbic acid concentration was observed. Eight of the twelve subjects showed no further rise in the plasma ascorbic acid level when the intake was increased to 107-110 mg per day. Daily urinary excretion of ascorbic acid was studied for three of the subjects during the last 30 days of the study. An intake of 82 mg was sufficient for these three subjects to reach saturation. When related to weight their retention or "utilization" values were approximately 1 mg ascorbic acid per kg of body weight.

Plasma ascorbic acid determinations were made at the beginning and conclusion of a 10 to 14 day experimental period in which the 56 subjects of Bryan et al. (1941) followed their usual diets but recorded weights of all food consumed. They reported 65 correlations on 56 subjects, showing that plasma ascorbic acid concentration increased in a more or less linear fashion with increasing dietary intake up to about 1.7 to 1.9 mg per kg per day at which time the plasma values approximated 1.0 mg per cent. This was considered the saturation level since a further increase of intake had little effect on plasma ascorbic acid concentration.

Experiments with Children:

Among younger age groups studies have been conducted with preschool and school age children. Everson and Daniels (1936) studied the retentions of ascorbic acid by following the urinary excretion of three boys 39, 57 and 59 months of age. Retentions of ascorbic acid paralleled the ingestions up to 7.5 mg per kg, but higher

ingestions were without influence on the retentions of the children studied. The highest retentions were found in the youngest child suggesting that possibly there is a greater demand for vitamin C by the younger tissue.

Hathaway and Meyer (1941) and Meyer and Hathaway (1944) also found that a daily intake of 31 mg of ascorbic acid was the marginal level for tissue saturation of the four subjects studied in 1939-40. A daily intake of 23-25 mg of ascorbic acid was not sufficient for tissue saturation in the eight children of the 1940-41 and 1941-42 studies. On the basis of their studies they concluded that the requirements of these children were not related to sex, age or body weight.

Roberts and Roberts (1942) studied five children 7 to 12 years of age, determining daily urinary excretion and occasional plasma values. A 300 mg test dose was given following each level of intake. The two youngest children required 65 mg of ascorbic acid, and the three oldest required 75 mg for saturation as determined by 50 per cent excretion of the test dose in 24 hours.

Dietary histories and blood plasma levels of 93 healthy city children were studied by Bessey and White (1942). They found that three ounces or more of orange juice or an equivalent amount of ascorbic acid (45 mg) in citrus fruits or tomatoes maintained a blood plasma level of 0.7 mg per cent, which they considered indicative of a liberal intake.

Thirty pre-adolescent girls, between 6 and 12 years of age,

were studied by Roberts et al (1943). Estimations of the dietary intakes for all subjects were based on ascorbic acid analyses of food eaten by six of the subjects over a week's period. Using plasma ascorbic acid values of 0.7 mg per cent and excretion in 24 hours of 50 per cent of a 300 mg test dose as the criteria indicating the satisfactory state of ascorbic acid nutrition, these workers found that intakes of 32 or 42 mg were not adequate. Only one subject on the 52 mg intake met the standard, while four-fifths of those receiving 62 mg and all receiving 72 mg of ascorbic acid were saturated. It was concluded that 62 to 72 mg of ascorbic acid were adequate for pre-adolescent girls.

Experiments with Adolescents:

Eight young adolescents, four boys and four girls, participated in a study reported by Storvick et al (1947). Fasting blood plasma ascorbic acid was determined daily during three one-week periods when the ascorbic acid intake was controlled. For these subjects it was found that the daily allowance of ascorbic acid recommended by the National Research Council (1945) resulted in plasma ascorbic acid values lower than those which they attained during the saturation period but well above 0.6 mg per cent, the quantity considered adequate by Butler (1940).

CHAPTER II

PURPOSE OF EXPERIMENTAL STUDY

The purpose of this investigation was to further the knowledge of ascorbic acid requirements of adolescents.

The requirements of eight girls and eight boys were determined by studying the concentration of ascorbic acid in the plasma on four levels of ascorbic acid intake for seven day periods in 1946-47, and three levels of ascorbic acid intake for ten day periods in 1947-48.

CHAPTER III

PLAN OF THE EXPERIMENT

Description of Subjects:

The subjects were selected through the elementary nutrition and chemistry classes, as it was felt that these students would have a better understanding of and be more interested in the study than students lacking a science background. All of the subjects were members of the freshman class and were presumably normal, healthy, older-adolescents. The description of the sixteen subjects, eight girls and eight boys, as to age, weight and height is given in Table I.

TABLE I

Description of Subjects

	Subject	Age	Mean Weight		Height
			Lbs.	Kg.	In.
1946-47					
Girls:	MG	18	119	54	61 1/4
	WH	16	125	57	67
	BR	19	130	59	65 3/4
	PS	18	111	50	59 1/2
Boys:	JC	18	155	70	71 1/2
	VD	18	156	70	69 1/4
	JJ	18	157	71	71
	GS	18	170	77	71 1/4
1947-48					
Girls:	NA	18	117	53	65 1/2
	BD	18	116	53	65
	MF	18	145	66	65 1/2
	RR	18	153	70	64 1/2
Boys:	TC	18	186	85	73 1/2
	DE	18	182	83	73 1/2
	WP	18	129	59	66
	DR	18	151	69	70 1/2

The subjects were only moderately active with the exception of JJ who was very active. They carried full class schedules, each including a physical education course, and they participated in various extracurricular activities.

Prior to the studies the dietary backgrounds of the subjects varied. The girls, PS, MG and RR had eaten at the Memorial Union cafeteria, BR ate at a sorority house, NA and BD ate at a girls' cooperative house, MF ate at Waldo Hall, a girls' dormitory, and WH ate with her brother and his family with whom she lived. All of the boys ate their meals in the quonset cafeteria, except WP who ate at a private boarding house off campus.

Experimental Periods in 1946-47 Studies:

In the 1946-47 studies, four one-week experimental periods were used for each of the two groups of subjects. During the first week the subjects ate the regular dormitory diet ad libitum, but all the food eaten was weighed and recorded. The second week was the saturation period and during this time the subjects were given 200 mg of crystalline ascorbic acid[1] daily in addition to the regular dormitory diet. During the third and fourth weeks of the study, the ascorbic acid intake from food was restricted to 20 mg or less by substituting foods of lower ascorbic acid content for those foods on the menu which were high in ascorbic acid. Supplements of crystalline

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1 The author is indebted to Merck & Co., Inc., Rahway, New Jersey for a generous supply of crystalline ascorbic acid.

ascorbic acid were given during the third period so that the total ascorbic acid intake was equal to the recommended allowances of the National Research Council for the age and sex of the particular subjects. A decrease of 10 mg in the crystalline ascorbic acid supplement was made during the fourth period, thus the total intake was 10 mg less than the recommended allowances of the National Research Council.

Experimental Periods in 1947-48 Studies:

The 1947-48 studies were divided into three ten-day periods rather than into four one-week periods as in the 1946-47 studies. It was felt that it might be more valuable to omit the orientation period on the usual diet and to have the other three periods extended to ten days rather than have four periods of one week each. This longer experimental period allowed more time for adjustment to a new level of ascorbic acid intake. During the first ten days the subjects were given 200 mg of crystalline ascorbic acid plus the amount present in the foods on the usual dormitory diet. Again during the second and third periods, the food ascorbic acid was limited to 20 mg or less. During the second period a supplement of crystalline ascorbic acid was given so that the total ascorbic acid intake was equal to the recommended allowance of the National Research Council. During the third period the crystalline supplement was decreased by 10 mg making the total ascorbic acid intake 10 mg less than the recommended allowance of the National Research Council.

CHAPTER IV

EXPERIMENTAL PROCEDURE

General Daily Procedure:

The general procedure for the day was as follows: the subjects reported to the research laboratory at 6:45 AM, weighed themselves and recorded their weights on the chart posted in the laboratory. Next they warmed their hands in running hot water. The blood samples were taken by finger puncture and after the samples were checked to see that there was no hemolysis, the subjects were given their crystalline ascorbic acid supplements, except during the first week of the 1946-47 study when no additional ascorbic acid was administered. The subjects reported to the dormitory (or cafeteria) at meal times where all their food was weighed for them. No food was eaten between meals, but black coffee was permitted ad libitum. After the evening meal of the third and fourth periods of the 1946-47 studies and the second and third periods of the 1947-48 studies, the subjects again reported to the laboratory to receive an additional supplement to make up the difference between the amount of ascorbic acid actually obtained and the 20 mg which were allowed from food each day.

Food Service:

The studies with the girls were conducted at Snell Hall, a girls' dormitory, conveniently located near the Home Economics Building. This dormitory was selected because the dining hall had table rather than cafeteria style service. A table near the kitchen was selected

for the experimental subjects and the research workers. The cold foods were weighed before the dinner bell rang so that full attention could be given to weighing the hot foods at the last minute. Bowls of the different foods were brought to the table where individual portions were weighed for the subjects. As far as was possible, each food was kept separate, for example, cottage cheese, pineapple and lettuce which were to be made into a salad were brought to the table in three separate bowls and each ingredient was weighed as the salad was made. In the same manner, whipped cream or sauces were weighed separately from the foods on which they were served.

The studies with the boys were carried out at the Memorial Union cafeteria. Since all the meal service for boys on the campus is cafeteria service, the Memorial Union was selected because of its convenient location to the Home Economics Building. Cafeteria service brought up different problems but a routine was worked out so that one person went through the serving line just before the serving period started and picked up all the cold foods for the entire group. These were weighed at the table and placed on the individual trays. At the time the subjects arrived, another trip was made through the line to pick up the hot foods.

All the food which the subjects ate was weighed on a Chatillon balance immediately before serving. Milk was weighed directly into glasses. Other food was weighed on small tin pie plates and transferred to individual trays or plates. Standard portions of 100 gm of fruit and vegetables were served except when there was a limited

supply available or possible high ascorbic acid content made it necessary to decrease the size of the portion during the periods when the ascorbic acid from the food was restricted. Larger portions of a few foods (e.g. potatoes) were served during the unrestricted periods if requested by the students.

During the periods when the total ascorbic acid intake was not restricted, fruits with pits or rinds and meat with bone and gristle were weighed intact for each subject. After the meal the inedible portions were weighed back and that amount was subtracted from the original weight of the serving. When identical servings were desired for each subject throughout the periods of limited ascorbic acid intake, the pits or rinds were first removed and then identical servings were weighed. Meat continued to be weighed as in the earlier periods since it was not analyzed and equal servings were not necessarily given to each subject.

The food service in the living units on the campus is supervised by the Department of Dormitories. Menus come from the dormitory office and may be changed by each dining room manager to comply with the facilities for preparation and serving in her own particular food service unit. At Snell Hall, during 1946-47, the manager did not serve citrus fruits at breakfast because she felt that many of the girls did not get up for this meal and would not get an adequate supply of ascorbic acid. The citrus fruits were, therefore, served in salads and desserts at other meals but from the author's observations the quantity used in this manner was not equivalent to the

amount one would receive in a whole orange or half of a grapefruit. The Memorial Union service, using partitioned trays instead of plates, presented difficulties in serving some foods but whole oranges and grapefruit halves could be used conveniently and appeared very frequently as breakfast fruits.

Difficulty in analysis was encountered with several foods. Meats in general were not sampled for analysis but one evening out of curiosity liver was analyzed and found to have a value of 25.68 mg per 100 gm. It was felt that this probably was not wholly ascorbic acid but was due to some interfering reducing substance. Potato chips also gave upon analysis a higher ascorbic acid value than was expected, i.e., 32.42 mg and 24.11 mg per 100 gm. Vegetable soup was another food that caused difficulty. Two analyses of vegetable soup had given low values (0.00 and 2.00 mg per 100 gm) so one day when food ascorbic acid was being restricted to 20 mg, 350 gm of vegetable soup were served to each boy. This particular soup analyzed at 5.13 mg per 100 gm, so considering the other foods already served that day, the 20 mg daily allotment had been exceeded. As a result of these experiences, liver and potato chips were excluded from the diet and it was decided that vegetable soup should be analyzed before being served.

Analytical Methods:

Determination of Reduced Ascorbic Acid in Foods

The method of Loeffler and Ponting (1942) was followed for the analysis of foods. The equipment used for this procedure was

as follows:

1. Evelyn Photoelectric Colorimeter with filter no. 520
2. Waring Blendor Units
3. Fast flowing pipette calibrated at 9 ml (or syringe pipette)*
4. Stop Watch
5. Funnels
6. Evelyn Test Tubes, checked for uniformity
7. One-ounce Glasses
8. One ml quantitative pipettes (or syringe pipettes)*

The reagents were prepared in the following manner:

1. 1% metaphosphoric acid (fresh daily)

   It was found convenient to make a 6% solution by weighing out 42 gm of HPO_3 and making up to 700 ml with water at night. The acid was dissolved by morning and diluted from this concentrated 6% solution to the 1% solution as needed.

2. Sodium 2, 6-dichlorobenzenoneindophenol

   120 mg of dye were made to 1 liter with distilled

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* During the second year, syringe pipettes were found to be very helpful in the analytical procedure. They are made for syringes of different sizes and are adjustable so that the pipette will rapidly deliver a constant amount of solution. They may be obtained from:
  Mr. H. Ruff
  Northern Tool and Instrument Co.
  164-21 Northern Blvd.
  Flushing, New York

water. This concentrated dye was made weekly and diluted daily 1:10 for use. When the galvanometer was set at 100, 9 ml of the diluted dye and 1 ml of HPO_3 gave a galvanometer reading of approximately 30.

Any food which was known to contain or thought to contain ascorbic acid was analyzed for reduced ascorbic acid by the method of Loeffler and Ponting (1942). All fruits, vegetables and dairy products except milk were analyzed each time they appeared on the menu. Milk, delivered once a day at the dining halls, was analyzed each morning. Any mixture made with vitamin C containing foods was analyzed. Condiments, pickles and relishes were tested for possible ascorbic acid content.

Samples of liquids to be analyzed were placed in chemically clean one-half pint Mason jars and taken immediately to the laboratory for analysis. A ten gram portion was weighed into a beaker on a trip balance, 70 ml of 1% HPO_3 added and the contents stirred before being filtered through coarse filter paper.

Solid foods were sampled at the dining halls at the time the food for the subjects was weighed. Twenty-five gram portions of food known to contain relatively large amounts of ascorbic acid (e.g., orange sections, tomato, cabbage and grapefruit) and fifty-gram portions of foods containing smaller amounts of ascorbic acid were weighed directly into one-half pint Mason jars. A 100 ml portion of 1% HPO_3 was added from a graduated cylinder. The samples

were taken immediately to the laboratory for analysis.

The contents of each Mason jar were transferred quantitatively into a Waring Blendor unit using 250 ml of 1% HPO_3 to make a total of 350 ml of acid. This is a proportion of seven parts of acid to one part of food for 50-gram samples or 14 parts of acid to 1 part of food for 25-gram samples. Loeffler and Ponting recommend a proportion of not less than 7 parts acid to 1 part food. The mixture was blended for five minutes, allowed to settle a little and filtered through coarse filter paper into one-ounce glasses. The clear filtrate containing the ascorbic acid was analyzed colorimetrically using an Evelyn Colorimeter with filter 520 to measure the color intensity. The details of the procedure are as follows:

1. The galvanometer of the instrument was set at 100 with distilled water in a test tube checked for uniformity. One ml of 1% HPO_3 was introduced into 1 of 5 matched test tubes and 9 ml of dye added within 5 seconds from a fast flowing pipette or syringe pipette. The contents were agitated and read in the colorimeter 15 seconds after the beginning of the addition of the dye. This value was recorded as the blank or G_1 value.
2. One ml aliquots of the sample filtrate were placed in each of the four remaining test tubes. Nine ml of water were added to the first tube and the galvanometer set at 100 to correct for color and turbidity

of the sample.

3. Nine ml of dye were added to the first of the other three tubes and readings were made at 15 seconds (G_{15}) and 30 seconds (G_{30}) after the beginning of the addition of the dye. The difference between G_{30} and G_{15} representing the reduction of the dye by non-specific reducing substances, was subtracted from the G_{15} value and recorded as G_2. This value represents the dye reduction at zero time. It has been shown by Evelyn (1938) that ascorbic acid is reduced practically instantaneously while interfering substances react with the dye more slowly. Therefore, the G_2 value may be taken to represent the dye reaction due to ascorbic acid alone.

4. The aliquots in the other two tubes were analyzed in the same manner. The G_1 and G_2 values were corrected for galvanometer variation by reference to the chart furnished with the instrument. The average corrected blank (G_1) reading for the determinations of all the foods of a single meal was used in calculating the ascorbic acid content. L_1 and L_2 values corresponding to the corrected G_1 and G_2 values were recorded from the table supplied with the instrument where $L_1 = 2\text{-}\log G_1$ and $L_2 = 2\text{-}\log G_2$. The average L_2 value for each series of three test tubes was used in calculating the ascorbic acid content of the food.

5. Calculation: The ascorbic acid content of the food expressed as mg per 100 gm was calculated using the following formula:

$$\text{MG. AA/100 Gm food} = \frac{K(L_1-L_2)(\text{Weight of acid} + \text{Weight of sample})}{\text{Weight of sample}}$$

K, a constant determined by analyzing standard ascorbic acid solutions, was found to be 10.86 in 1946-47 and 10.85 in 1947-48. The weight of each food sample was taken to represent the weight of water it contained since most of the fruits and vegetables analyzed contain 90 per cent water.

Sample Calculation:

Food	Wt. of Sample	HPO_3	G_1	Corr. G_1	G_{15}	G_{30}	$G_{15}-G_{30}$	G_2	Corr. G_2	L_1	L_2	L_1-L_2	A.A.
	gm	ml											mg %
Pine-apple	50	350	31	31^2	37	37^2	0^2	36^2	37^1	0.502	0.429	0.073	6.60
					37^2	38	0^2	37	37^3		0.423	0.079	
					37^1	37^3	0^2	36^3	37^2		0.426	0.076	
												Av. 0.076	

Calculation:

Concentration as Mg/100 gm =

$$\frac{K(L_1 - L_2)(\text{Weight of acid} + \text{Weight of sample})}{\text{Weight of sample}}$$

$$C = (10.86)(0.076)\left(\frac{400}{50}\right) = 6.60 \text{ mg/100 gm}$$

Determination of Reduced Ascorbic Acid in Plasma

Determinations of fasting plasma ascorbic acid were made daily by the micro-method of Farmer and Abt (1939). The following equipment was used in this procedure:

1. Oxalated blood vials
2. Clean vials for centrifuging deproteinized plasma
3. 0.2 ml pipettes
4. Microburette, (special design of Farmer and Abt, obtained from Sargent & Company, Chicago)
5. Spot plates
6. Lancet
7. Slender glass stirring rods (about 3" long) made by drawing out solid glass rod.
8. Small corks for vials
9. Pointed glass stirring rods for titrating
10. Clinical centrifuge

The reagents were prepared as follows:

1. Lithium oxalate, 2 per cent solution
2. Mercury
3. 5 per cent metaphosphoric acid (fresh daily)
4. 2½ per cent metaphosphoric acid (fresh daily)
5. Dye: 0.2 gm of sodium 2,6-dichlorobenzenoneindophenol and 50 ml of 6.8 phosphate buffer are made up to 500 ml with redistilled water. Dilute 1:10 for use.
6. Standard ascorbic acid solutions: 40 mg ascorbic acid

were placed into a 100 ml volumetric flask. Twenty ml of 2 per cent sulfuric acid containing 2 per cent metaphosphoric acid were added and the solution made up to 100 ml with redistilled water.

For the standardization, 2 ml of the above solution were diluted to 100 ml with redistilled water. The standard ascorbic acid solutions which were titrated contained 0.008 mg ascorbic acid per ml.

Dilutions were made from two standard solutions for standardizing the dye. A third standard was prepared and diluted if good checks were not obtained with the first two.

7. Blank Solution: Twenty ml of 2 per cent sulfuric acid containing 2 per cent metaphosphoric acid were made up to 100 ml with redistilled water. Two ml of this solution were diluted to 100 ml with redistilled water before using.

8. Phosphate Buffer pH 6.8: Prepared by combining equal volumes of N/15 $Na_2HPO_4 \cdot 2H_2O$ (11.8711 gm per liter) and N/15 KH_2PO_4 (9.0760 gm per liter).

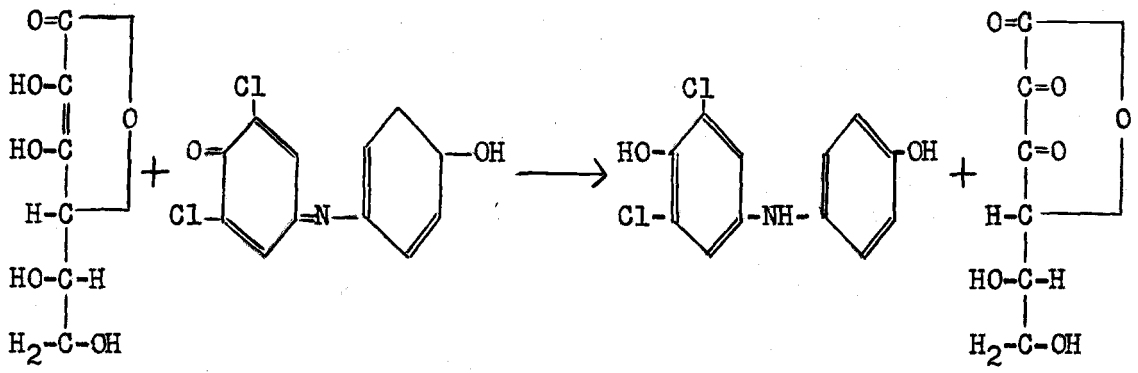
Standardization of the Dye:

1. A rubber tube with glass stopper at one end was filled with clean mercury and put on the straight end of the microburette. The microburette was filled with the dye by holding the curved tip in the dye solution and turning

the screw of the microburette holder clockwise until a small drop of the mercury was expelled into the dye solution, and then filled to the desired point by turning the screw in the reverse direction.

2. Three 0.2 ml aliquots of each of the standard ascorbic acid solutions were transferred to depressions of the spot plate and were titrated with 2,6-dichlorobenzenoneindophenol using the Farmer and Abt microburette. The dye was added until a faint pink color appeared. 0.2 ml, of $2\frac{1}{2}$ per cent metaphosphoric acid which had been pipetted into an adjacent depression in the spot plate was titrated with the dye until the faint pink color matched the ascorbic acid sample.

The equation for the chemical reaction which occurs in the titration is as follows:



Ascorbic acid

2,6-dichlorobenzenoneindophenol (blue in alkali, red in acid)

Reduced indicator (colorless)

Dehydroascorbic acid

3. Calculation:

$$\frac{\text{AA in aliquot}}{\text{ml dye used for aliquot - ml dye used for blank}} = \text{dye equivalent}$$

Example:

Standard Solution	Sample	Titre with Dye		Sample - Blank	Dye Equivalent
		Sample	Blank		
	Ml	Ml	Ml	Ml	
I	0.2	0.0840	0.0035	0.0805	0.0199

$$\frac{0.0016}{0.0840 - 0.0035} = 0.0199$$

Titration of the Plasma:

1. Blood was collected by finger prick into an oxalated vial, stirred with a fine glass stirring rod, stoppered and centrifuged for 3 to 5 minutes.
2. Into a conical tip vial 0.1 ml of plasma and 0.1 ml of re-distilled water were pipetted with the same pipette. Then 0.2 ml of 5 per cent metaphosphoric acid was added and mixed thoroughly by tapping the vial against the palm of the hand. The coagulated protein was centrifuged down (about 5 minutes).
3. Two 0.2 ml aliquots of deproteinized plasma were transferred to each of two depressions in the spot plate and titrated with a solution of sodium 2,6-dichlorobenzenoneindophenol until a faint pink color appeared. In an adjacent depression of the spot plate 0.2 ml of $2\frac{1}{2}$ per cent metaphosphoric acid was titrated with the dye until the faint pink color matched

the color of the titrated plasma sample.

4. Calculation:

(ml dye used for AA in plasma - ml dye used for blank)(dye equivalent)(2000) = mg AA per 100 ml blood plasma

Example:

Subject	Sample	Titre with Dye		Sample-Blank	Dye Equivalent	Plasma AA
		Sample	Blank			
	ml	ml	ml	ml		mg %
Mary Smith	0.2	0.0145	0.0045	0.0100	0.0199	0.398*

* (0.0145 - 0.0045)(0.0199)(2000) = 0.398 mg %.

CHAPTER V

RESULTS AND DISCUSSION

Results and Discussion of Food Analysis:

The various foods analyzed, the number of times they were served and average mg of ascorbic acid per 100 gm of food are shown in Table IV in the appendix. The number of times each food was served refers to the times they were served to our subjects and not necessarily the frequency with which they appeared on the dormitory menus. During the third and fourth periods of the 1946-47 studies and the second and third periods of the 1947-48 studies the foods of high ascorbic acid content were replaced in the diet by foods low in ascorbic acid. Thus, for example, our records show that peaches were served more frequently and that oranges and grapefruit appeared fewer times for our subjects than on the regular dormitory menu. It was necessary to make such substitutions in order to keep the ascorbic acid content of the diet low, i.e., 20 mg or less, so that the larger part of the ascorbic acid intake could be given as crystalline ascorbic acid which was accurately weighed on an analytical balance.

In the foods as served, no consistent differences could be observed between those served at Snell Hall and the Memorial Union. At both the dormitory and the Memorial Union there were variations in the ascorbic acid content of any particular food at the different times it was served.

The greatest differences as far as food intake was concerned were

found in the quantities of food eaten by the subjects. The boys ate much larger quantities of food, especially of such food as bread, potatoes and sweet rolls. The girls, on the other hand, were conscious of their weights and they wanted to eat a minimum of those foods which they thought were fattening. All of the subjects were very cooperative about eating the foods served to them which was as expected since the routine and requirements of the study had been carefully explained to them before they agreed to participate in it.

Results and Discussion of Plasma Analysis:

The daily fasting plasma ascorbic acid values for each subject, their total daily ascorbic acid intake and their respective means are given in Tables V-A, V-B, V-C and V-D in the Appendix. Deviations from the means and the average mean deviations are also given. During the 1946-47 studies, the plasma values for all of the days in the first or orientation period of each study, were considered in the calculations since no attempt was made to control the ascorbic acid intake for this period. For the second, third and fourth periods, the plasma values were averaged for the last five days, thus allowing two days for the subjects to adjust to the new levels of intake. In the 1947-48 studies the mean values have been calculated both on the basis of the last eight days and on the last five days, which means in the first instance, that two days have been allowed for adjustment to the new levels of intake and in the latter case five days have been allowed for this adjustment. The purpose of these two sets of calculations was to show whether the longer experimental periods were really

necessary (Table VI in the Appendix). All of the daily ascorbic acid intake values were averaged in every experimental period. Tables II-A and II-B present a summary of the data for each subject including their mean ascorbic acid intake, mean plasma ascorbic acid values and their ranges of intake and plasma during each experimental period. The ascorbic acid intakes during the last two periods of the studies of both years are also expressed in mg of ascorbic acid per kg of body weight.

The significance of the differences between the means has been tested statistically. The difference was considered significant if it was twice as large as the standard deviation of the differences.

Girls:

In the first, or orientation period, of the girls' study in 1946-47, three of the four girls showed near-saturation values according to the results of fasting plasma ascorbic acid determinations (Fig. 1 and Table II-A). The mean fasting plasma ascorbic acid values were 1.00 mg per cent or higher for three of the subjects during this period. WH's value (0.61 mg per cent) was considerably lower than those of the other girls. This lower value was probably due to a previous diet which was low in citrus fruits and other sources of ascorbic acid. She was living with her brother and his family, while her brother was attending school under the G.I. Bill, so food expenditures necessarily were kept at a minimum. The mean daily intake for the group was 73 mg of ascorbic acid, ranging from 64 to 78 mg for the individual subjects. The steady decrease in plasma ascorbic acid

Table II

Summary of Mean Ascorbic Acid Intake, Mean Plasma Ascorbic Acid Values and Their Respective Ranges for Each Subject

A. Adolescent Girls

Subject	Usual Diet Period		Saturation Period			N.R.C. Recommended Allowance				10 Mgs Less than N.R.C. Recommended Allowance			
	Mean A.A. Intake	Mean A.A. in Plasma All days of Period	Mean A.A. Intake	Mean A.A. in Plasma		Mean A.A. Intake		Mean A.A. in Plasma		Mean A.A. Intake		Mean A.A. in Plasma	
				Last 8 days of period	Last 5 days of period			Last 8 days of period	Last 5 days of period			Last 8 days of period	Last 5 days of period
	Mg/day	Mg %	Mg/day	Mg %	Mg %	Mg/day	Mg/kg	Mg %	Mg %	Mg/day	Mg/kg	Mg %	Mg %
1946-47													
M.G.	641± 242 (17-112)3	1.01 ± 0.17 (0.67-1.33)	219 ± 4 (210-226)		1.13 ± 0.03 (1.04-1.19)	82 ± 4 (78-99)	1.5		0.99 ± 0.10 (0.88-1.15)	71 ± 2 (70-74)	1.3		0.86 ± 0.07 (0.75-0.93)
W.H.	76 ± 33 (28-175)	0.61 ± 0.14 (0.20-0.78)	219 ± 4 (210-226)		1.11 ± 0.11 (1.00-1.30)	83 ± 5 (78-101)	1.5		0.96 ± 0.07 (0.80-1.06)	71 ± 2 (70-74)	1.2		0.80 ± 0.05 (0.72-0.86)
B.R.	78 ± 35 (30-200)	1.00 ± 0.12 (0.81-1.25)	219 ± 4 (210-226)		1.15 ± 0.04 (1.07-1.24)	82 ± 4 (78-95)	1.4		0.97 ± 0.03 (0.93-1.00)	71 ± 2 (70-74)	1.2		0.92 ± 0.06 (0.86-0.99)
P.S.	75 ± 36 (16-187)	1.08 ± 0.10 (0.79-1.26)	219 ± 4 (210-226)		1.21 ± 0.06 (1.13-1.29)	80 ± 1 (78-82)	1.6		1.07 ± 0.08 (0.87-1.16)	71 ± 2 (70-74)	1.4		1.04 ± 0.10 (0.86-1.15)
1947-48													
N.A.			261 ± 11 (243-289)	1.03 ± 0.05 (0.90-1.10)	1.02 ± 0.07 (0.90-1.10)	80 ± 0.4 (78-81)	1.5	0.85 ± 0.07 (0.73-0.94)	0.83 ± 0.08 (0.73-0.94)	70 ± 0.3 (69-72)	1.3	0.81 ± 0.05 (0.69-0.87)	0.82 ± 0.04 (0.72-0.86)
B.D.			261 ± 11 (243-289)	1.18 ± 0.07 (1.09-1.29)	1.19 ± 0.06 (1.12-1.29)	80 ± 0.4 (78-81)	1.5	0.88 ± 0.06 (0.78-0.98)	0.90 ± 0.05 (0.78-0.98)	70 ± 0.3 (69-72)	1.3	0.91 ± 0.07 (0.77-1.02)	0.95 ± 0.06 (0.82-1.02)
M.F.			261 ± 11 (243-289)	1.25 ± 0.12 (1.10-1.42)	1.26 ± 0.10 (1.10-1.42)	80 ± 0.4 (78-81)	1.2	0.97 ± 0.08 (0.87-1.05)	0.98 ± 0.04 (0.93-1.04)	70 ± 0.3 (69-72)	1.1	0.96 ± 0.02 (0.93-1.01)	0.96 ± 0.02 (0.94-0.99)
R.R.			261 ± 11 (243-289)	1.22 ± 0.12 (0.94-1.40)	1.27 ± 0.06 (1.17-1.40)	80 ± 0.4 (78-81)	1.1	1.03 ± 0.04 (0.98-1.09)	1.02 ± 0.04 (0.98-1.09)	70 ± 0.3 (69-72)	1.0	0.98 ± 0.04 (0.94-1.04)	0.99 ± 0.04 (0.94-1.04)

1 Mean
2 Average deviation from the mean
3 Range

Table II

Summary of Mean Ascorbic Acid Intake, Mean Plasma Ascorbic Acid Values and Their Respective Ranges for Each Subject

B. Adolescent Boys

Subject	Usual Diet Period		Saturation Period			N.R.C. Recommended Allowance				10 Mgs Less than N.R.C. Recommended Allowance			
	Mean A.A. Intake	Mean A.A. in Plasma All days of Period	Mean A.A. Intake	Mean A.A. in Plasma		Mean A.A. Intake		Mean A.A. in Plasma		Mean A.A. Intake		Mean A.A. in Plasma	
				Last 8 days of period	Last 5 days of period			Last 8 days of period	Last 5 days of period			Last 8 days of period	Last 5 days of period
	Mg/day	Mg %	Mg/day	Mg %	Mg %	Mg/day	Mg/kg	Mg %	Mg %	Mg/day	Mg/kg	Mg %	Mg %
1946-47													
J.C.	116[1] ± 31[2] (22-159)[3]	0.78 ± 0.07 (0.66-0.92)	319 ± 45 (260-413)		1.07 ± 0.10 (0.93-1.24)	100 ± 0 (100-102)	1.4		0.91 ± 0.06 (0.82-0.99)	92 ± 3 (90-105)	1.3		0.79 ± 0.07 (0.63-0.86)
V.D.	130 ± 54 (21-296)	0.39 ± 0.11 (0.18-0.66)	357 ± 69 (264-486)		1.01 ± 0.09 (0.89-1.22)	100 ± 0 (100-102)	1.4		0.82 ± 0.04 (0.72-0.85)	92 ± 3 (90-105)	1.3		0.75 ± 0.07 (0.68-0.88)
J.J.	102 ± 32 (24-164)	0.39 ± 0.04 (0.33-0.45)	327 ± 47 (266-421)		0.90 ± 0.11 (0.68-1.12)	100 ± 0 (100-102)	1.4		0.90 ± 0.05 (0.84-1.02)	92 ± 3 (90-105)	1.3		0.80 ± 0.07 (0.69-0.96)
G.S.	130 ± 40 (21-198)	0.61 ± 0.13 (0.39-0.89)	324 ± 47 (263-424)		1.07 ± 0.03 (1.00-1.13)	100 ± 0 (100-102)	1.3		0.86 ± 0.04 (0.77-0.95)	92 ± 3 (90-105)	1.2		0.84 ± 0.04 (0.79-0.94)
1947-48													
T.C.			272 ± 25 (243-311)	0.80 ± 0.44 (0.39-1.31)	0.99 ± 0.20 (0.63-1.31)	100 ± 0.4 (99-101)	1.2	0.90 ± 0.06 (0.84-0.96)	0.90 ± 0.02 (0.84-0.91)	90 ± 0.6 (87-92)	1.1	0.82 ± 0.09 (0.69-0.93)	0.84 ± 0.05 (0.76-0.93)
D.E.			270 ± 29 (240-320)	0.71 ± 0.32 (0.38-1.06)	0.88 ± 0.10 (0.63-1.06)	100 ± 0.4 (99-101)	1.2	0.69 ± 0.10 (0.62-0.77)	0.67 ± 0.04 (0.62-0.74)	90 ± 0.6 (87-92)	1.1	0.67 ± 0.03 (0.61-0.71)	0.68 ± 0.02 (0.65-0.71)
W.P.			270 ± 27 (243-318)	1.11 ± 0.11 (0.99-1.32)	1.12 ± 0.09 (0.99-1.32)	100 ± 0.4 (99-101)	1.7	0.79 ± 0.09 (0.72-0.85)	0.81 ± 0.04 (0.75-0.85)	90 ± 0.6 (87-92)	1.5	0.72 ± 0.07 (0.62-0.88)	0.74 ± 0.06 (0.69-0.88)
D.R.			265 ± 21 (243-298)	1.04 ± 0.17 (0.87-1.18)	1.09 ± 0.06 (0.94-1.18)	100 ± 0.4 (99-101)	1.4	0.73 ± 0.09 (0.64-0.84)	0.69 ± 0.02 (0.64-0.72)	90 ± 0.6 (87-92)	1.3	0.73 ± 0.09 (0.59-0.89)	0.74 ± 0.08 (0.59-0.83)

1 Mean
2 Average Deviation from the mean
3 Range

shown by MG during the early part of this first period may be explained by the fact that prior to the study she was probably in a state of saturation due to the high intake of fruits. The day before the study began she had eaten six oranges.

A rise in plasma ascorbic acid values was observed in all cases with the ingestion of saturation levels of ascorbic acid during the second period. WH showed a rapid rise until her value was in the same range as the other subjects. Although the other three subjects appeared to be saturated, WH possibly may not have been since on the last day of the saturation period her plasma value was the highest she had shown. There is a question, therefore, as to whether a further increase would have been shown if the period had been extended.

There was a significant decrease in the plasma ascorbic acid concentration in all subjects when the mean level of ascorbic acid intake was decreased for the third period to 82 mg[1] which is slightly higher than the 80 mg recommended allowance of the National Research Council. During the previous week the mean intake had been 219 mg, so that 82 mg is a decrease of 137 mg from the previous intake. The mean plasma values during this period were very similar to the mean plasma values of each subject during the first period with the exception of WH, whose value remained 0.35 mg per cent higher than her mean value for

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1 A mean intake of 80 mg of ascorbic acid had been the aim for this period, and this had been achieved except for the last day of the period when a high value for liver was obtained.

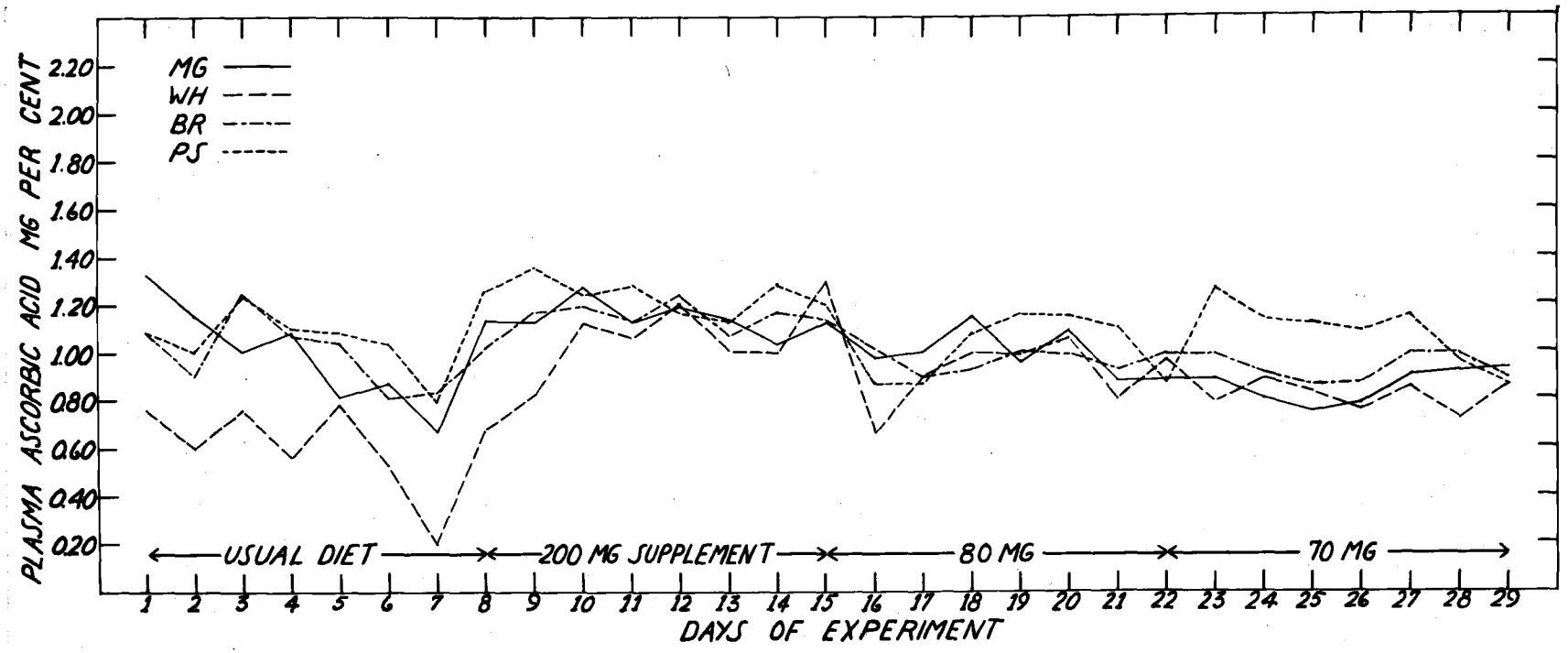

FIGURE 1. DAILY PLASMA ASCORBIC ACID VALUES OF THE GIRLS, 1946-47.

the first period. WH's mean plasma value was however very similar to those of the other subjects during the third period.

A further significant decrease in plasma ascorbic acid values was shown by two subjects (MG and WH) during the fourth period when the mean ascorbic acid intake was 71 mg, or 11 mg less than during the third period. A decrease in mean plasma ascorbic acid content of 0.13 and 0.16 mg per cent was shown by MG and WH respectively, between the third and fourth periods, while the values of BR and PS showed respective decreases of only 0.05 and 0.03 mg per cent. PS was the only subject whose plasma value did not "level off" at this particular intake. WH had a mean plasma value of 0.80 mg per cent which was lower than the other subjects. She was the youngest subject, being 16 years of age, and it may be that she had a higher requirement for ascorbic acid.

The ten day saturation period during the 1947-48 study seems to have been sufficiently long for the plasma to become saturated in all four girls as indicated by a "leveling off" at plasma values above 1.00 mg per cent (Fig. 2 and Table II-A). The mean plasma values for the last five days of the period were 1.02, 1.19 1.26 and 1.27 mg per cent for NA, BD, MF and RR respectively.

A significant decrease in plasma ascorbic acid between the saturation period and the second period when the ascorbic acid intake was 80 mg per day was shown by all subjects, regardless of whether the plasma values of the last eight days or only the last five days of the period were considered. The decrease was 0.19, 0.29, 0.28 and 0.25 mg per

cent for the different subjects when considering the last five days of each period. The mean plasma values for the last five days remained above 0.80 mg per cent in all cases.

With these four subjects, a 10 mg decrease in the level of ascorbic acid intake (to a mean of 70 mg per day) resulted in no significant decrease in the plasma ascorbic acid values when calculated on the basis of the last five days, and in only one case was there a significant decrease when calculated on the last eight days of the period.

In the 1946-47 study with the girls the recommended allowance of the National Research Council of 80 mg of ascorbic acid per day appeared to maintain the plasma ascorbic acid at a concentration near 1.00 mg per cent for at least one week following a period of saturation. During the 1947-48 study the same level of intake maintained mean plasma values for the last five days of 0.83, 0.90 0.98 and 1.02 mg per cent in a ten day period following saturation. For all of the girls in both studies the mean fasting plasma values on the 80 mg level of ascorbic acid intake were all significantly lower than the mean plasma ascorbic acid values during saturation, but in no case was the mean below 0.80 mg per cent. With six of the eight subjects, the 70 mg intake of ascorbic acid appeared, under the conditions of these studies, to be equally as effective as was the 80 mg intake in maintaining the concentration of ascorbic acid in the plasma.

Boys:

The fairly low mean plasma ascorbic acid values of the boys (0.78, 0.39, 0.39 and 0.61 mg per cent) in the first period of the

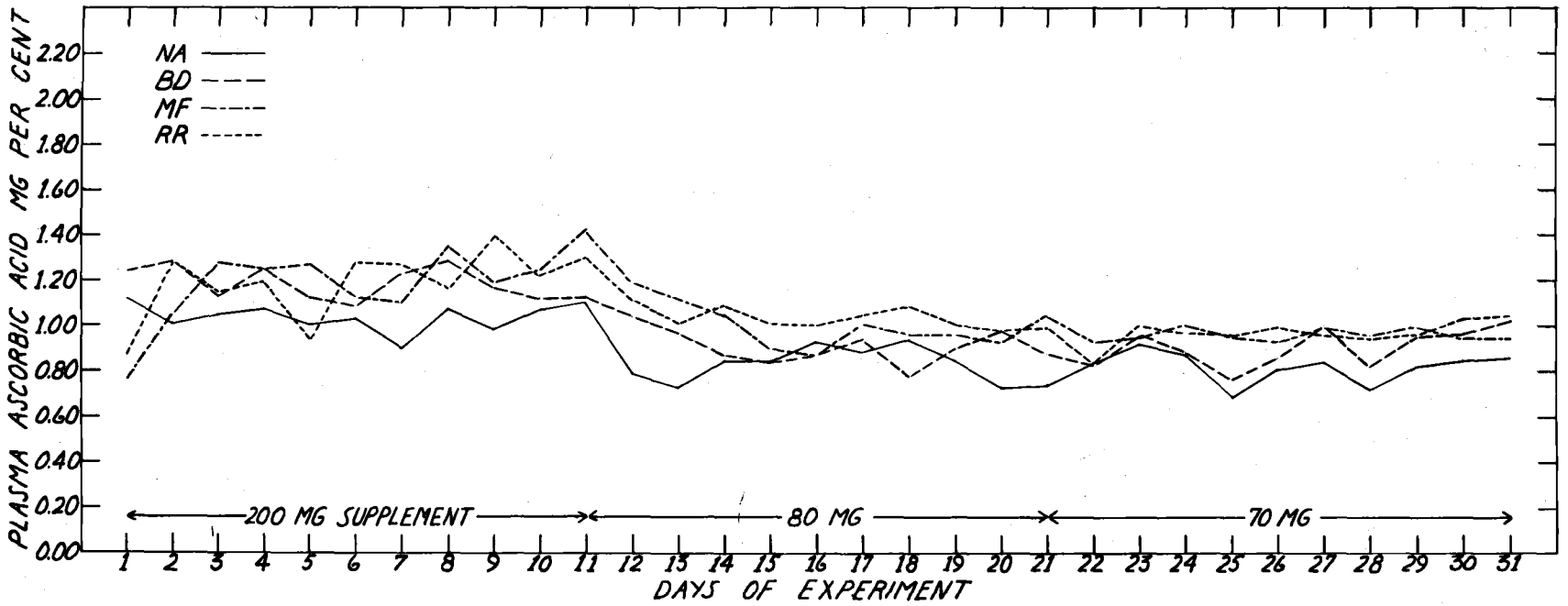

FIGURE 2. DAILY PLASMA ASCORBIC ACID VALUES OF THE GIRLS, 1947-48.

1946-47 study when the ascorbic acid intake was not controlled is a general indication of a previously poor intake which may be due to a number of causes (Fig. 3 and Table II-B). These subjects did not get up regularly for breakfast which is the meal when most of the citrus fruits were served. VD ate citrus fruits only occasionally because he did not care for them.

A marked rise in plasma ascorbic acid was observed in three of the subjects, JC, VD and GS, when 200 mg doses of ascorbic acid were given as supplements during the second or saturation week. Although the mean ascorbic acid intake during this saturation period was very high, 319 to 357 mg per day, it was questionable whether the subjects were saturated at the end of the week, particularly in the case of VD and GS whose values were still increasing day by day. A steady but more gradual rise was shown by JJ during this period, and his mean value for the period was considerably lower than those of the other subjects. On the fourth day of the saturation period JJ reported to the Student Health Service at the college where he was given a series of injections for poison oak. Ten days later he was confined to the infirmary with poison oak and a secondary infection of impetigo. While he was in the infirmary for three days he was given considerable medication including penicillin, sulfathiazole, phenobarbitol, nembutol and benzedrine. Calmitol ointment and ammoniated mercury were used locally on the infected areas. JJ remained on the experiment as a matter of interest although his data were not considered as those of a normal subject. His meals and supplements were carried to him and

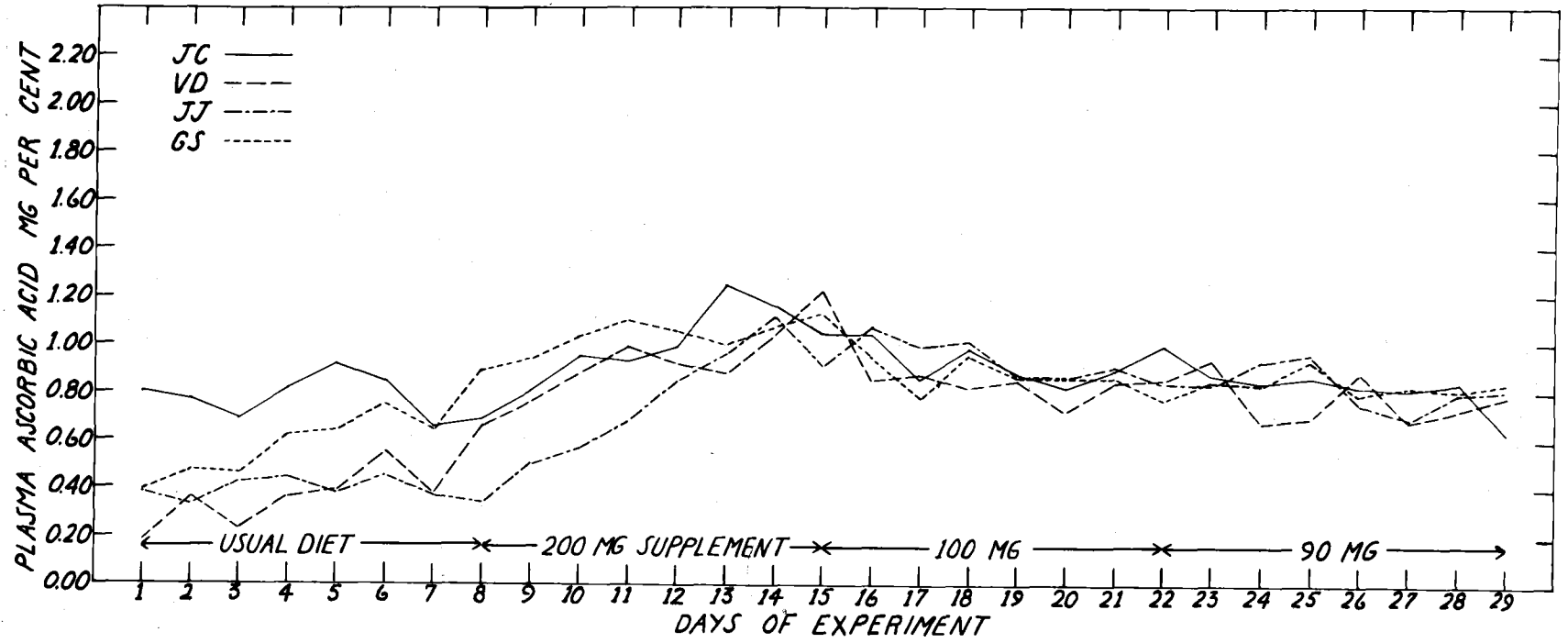

FIGURE 3. DAILY PLASMA ASCORBIC ACID VALUES OF THE BOYS, 1946-47.

someone from the nutrition laboratory collected his blood samples daily.

During the third week 100 mg of ascorbic acid, the recommended allowance of the National Research Council for this particular age, was given to the subjects. A marked downward trend was noticed in the blood plasma values at this time. The decrease in mean plasma values from the saturation period to the period of the 100 mg mean intake was 0.16, 0.19 and 0.21 mg per cent for JC, VD and GS respectively. These are significant changes according to statistical analysis. Although these means are not as high as the subjects' saturation means, they are in all cases above 0.80 mg per cent. The mean plasma value for JJ during this period remained the same as during the saturation period (0.90 mg per cent).

In the fourth period, when the ascorbic acid intake was decreased 10 mg, a further significant decrease in plasma ascorbic acid was shown only by JC. The plasma concentration of GS appeared to have reached a plateau by the end of the period at this level of intake but whether the plasma values of the other subjects had reached plateaus was not so convincing. The mean plasma ascorbic acid values for this period were 0.79, 0.75, 0.80 and 0.84 mg per cent for JC, VD, JJ and GS respectively.

In the 1947-48 study, the concentration of ascorbic acid in the plasma of WP and DR was indicative of saturation by the end of the 10 day saturation period (Fig 4 and Table II-B). DR showed fairly low plasma ascorbic acid values the first few days, but his plasma ascorbic

acid concentration rose rapidly after that time. At supper of the first day, DR reported that he was not feeling well, and by the next morning he had diarrhea accompanied by cold symptoms. On that day, he came to the cafeteria for his meals but did not eat all of the food. At the end of the day he was given 30 mg of crystalline ascorbic acid so that his total intake was similar to that of the other boys. DR felt better the next day and he returned to a more normal diet, eating at least those foods which were analyzed for ascorbic acid. By the third day of the study he had recovered completely. At the beginning of the study TC and DE had very low fasting plasma ascorbic acid concentrations, 0.21 and 0.34 mg per cent. The slowness with which their plasma concentrations increased even at the saturation level of ascorbic acid intake seemed to indicate prolonged ingestion of diets low in ascorbic acid prior to this study. This was confirmed by the subjects who stated that they did not eat breakfast and therefore did not have access to any fruit which might be served at that time. Neither of the boys allowed time for breakfast and although they both had good appetites, their preferences were for such foods as meat, potatoes, bread and sweet rolls rather than for fruits and vegetables. Throughout the saturation period their plasma values continued to rise so that the mean value for TC calculated on the data for eight days was 0.80 mg per cent but his mean value was 0.99 mg per cent when only the last five days were considered. For DE a similar difference in the mean was observed, i.e., 0.71 mg per cent on the data for eight days compared to 0.88 mg per cent on a basis of five days. From the plasma

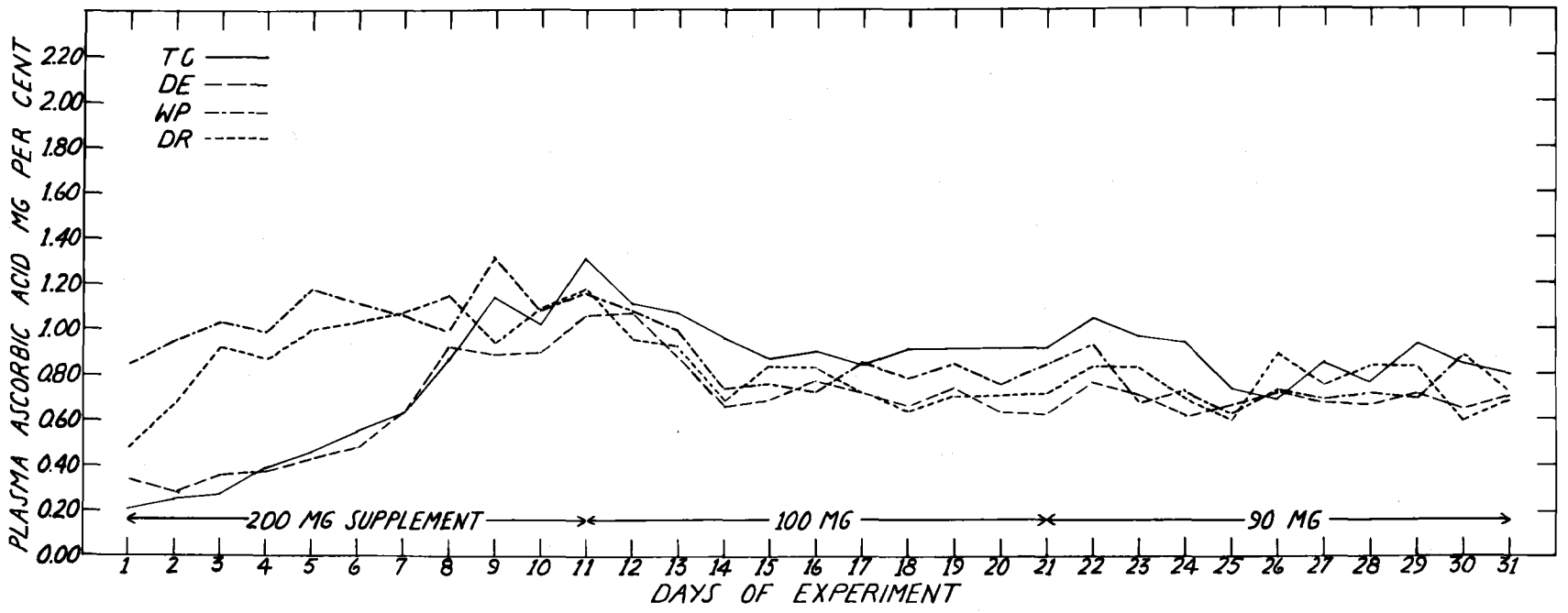

FIGURE 4. DAILY PLASMA ASCORBIC ACID VALUES OF THE BOYS, 1947-48.

values of the last few days of this period it would appear that they were approaching saturation but it cannot be said that they were definitely saturated.

When the intake of ascorbic acid was decreased to 100 mg in the second period, a significant lowering of the mean fasting plasma ascorbic acid occurred in all cases when calculated on the basis of the last five days of the experimental period. The means for this period were 0.90, 0.67, 0.81 and 0.69 mg per cent; the first two values are for the two subjects whose attainment of saturation was not convincing and the latter two from the two subjects who apparently were saturated in the previous period. Calculated on the basis of data from the last eight days of the period, only two of the subjects showed a significant decrease in the mean fasting plasma ascorbic acid content. The differences between the means of plasma ascorbic acid values were not significant for TC and DE, the two subjects who started the study with very low values.

A further decrease in the ascorbic acid intake to 90 mg made no significant difference in the mean fasting plasma ascorbic acid concentrations of all four subjects when calculated on the last five days of the experimental period. The calculations on the last eight days revealed inconsistent results, TC and WP showing a significant decrease between the means, whereas DE and DR did not. The mean plasma ascorbic acid values for the four subjects ranged from 0.68 to 0.84 mg per cent, with three of the four means below 0.80 mg per cent.

The mean plasma ascorbic acid values for all of the boys in the

studies of both years, with the exclusion of JJ's values, showed a significant decrease between the saturation period and the period when 100 mg of ascorbic acid were ingested. For six of these seven subjects, a 90 mg intake of ascorbic acid was as effective as 100 mg in maintaining the plasma concentration of ascorbic acid under the conditions of this study.

In addition to the above mentioned analysis of the results, the data of both years were also analyzed by analysis of variance (Snedecor, 1946).[1] A statistically significant difference was found between the means of the saturation period and the period on the recommended allowance of the National Research Council, while the difference in the means between the period on the recommended allowance and the period of 10 mg less than this amount was not statistically significant for the boys but was significant for the girls as based on the analysis of variance (Tables VII-A, VII-B, VIII-A and VIII-B in the Appendix). It was interesting to note that although the girls were ingesting 20 mg of ascorbic acid less than the boys during comparable periods they had a significantly higher mean plasma ascorbic acid value than did the boys (Table IX in the Appendix).

The results of this study were similar to those found with the younger adolescent group previously studied in this laboratory, that is, the daily allowance of ascorbic acid recommended by the National

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1 The author is indebted to Dr. J. R. Li for assistance in the analysis of variance.

Research Council did not maintain the plasma values as high as during the saturation period. For 21 of the 23 subjects, eight younger adolescents (Storvick, et al, 1947) and fifteen older adolescents of this present study, the National Research Council recommended allowance maintained mean plasma values above 0.80 mg per cent under the conditions of these studies. The two exceptions were older adolescent boys.

The following table shows the mean plasma ascorbic acid concentrations for each subject on various levels of intake, with the intake expressed in terms of mg of ascorbic acid per kg of body weight.

Table III

Mean Concentrations of Plasma Ascorbic Acid Compared With Milligrams of Ascorbic Acid Ingested Per Kilogram of Body Weight

Ascorbic Acid Intake	Plasma Ascorbic Acid Concentrations	
	Girls	Boys
mg/kg	mg %	mg %
1.7		0.81
1.6	1.07	
1.5	0.99 0.96 0.83 0.90	0.74
1.4	0.97 1.04	0.91 0.82 0.90 0.69
1.3	0.86 0.82 0.95	0.86 0.79 0.75 0.80 0.74
1.2	0.80 0.92 0.98	0.84 0.90 0.67
1.1	1.02 0.96	0.84 0.68
1.0	0.99	

These plasma ascorbic acid concentrations seem to follow no particular pattern; thus, it is just another way of showing the varying responses of different individuals to the same levels of ascorbic acid intake.

CHAPTER VI

SUMMARY

1. The recommended allowance of the National Research Council, 100 mg for the 18 year old boys and 80 mg for the 16 to 19 year old girls did not maintain mean plasma values at levels as high as the respective saturation means. For the girls all the mean values were above 0.80 mg per cent (ranging from 0.83 to 1.07). The boys' values ranged from 0.67 to 0.91 mg per cent; two out of the seven values were below 0.80 mg per cent.

2. When the ascorbic acid intake was decreased to 10 mg less than the recommended allowance of the National Research Council, it was found that for six of the eight girls the 70 mg intake of ascorbic acid was as effective as the 80 mg intake in maintaining the ascorbic acid concentration of the plasma, and that for six of the seven boys, JJ's values were excluded, an intake of 90 mg of ascorbic acid was as effective as 100 mg in maintaining the plasma ascorbic acid concentration.

3. The plasma ascorbic acid concentrations of these subjects showed individual variations even when the ascorbic acid intake was considered on the basis of mg of ascorbic acid per kg of body weight.

4. The ten day experimental periods were more desirable than the periods of one week. This was particularly true for the saturation period when some of the subjects had been on diets low in ascorbic acid prior to the study.

5. The data in this study were analyzed statistically by testing the significance of differences between means and by analysis of variance.

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APPENDIX

Table IV

Ascorbic Acid Content of Food Served at
Oregon State College Dining Halls
(Average Ascorbic Acid as Mg/100 Gms)

Food	Snell Hall 1946-47	Snell Hall 1947-48	Memorial Union 1946-47	Memorial Union 1947-48
	Mg %	Mg %	Mg %	Mg %
FRUITS:				
Apple, baked	0.38 (3)*	---	0.00 (3)	---
Apple juice	0.43 (1)	0.70 (2)	0.00 (1)	0.23 (9)
Apple, raw	3.80 (4)	2.53 (3)	6.43 (1)	1.91 (1)
Applesauce	0.00 (1)	0.10 (5)	0.00 (2)	---
Apricots, canned	1.99 (7)	3.56 (5)	2.73 (3)	5.02 (7)
, juice	3.08 (6)	3.18 (3)	0.61 (1)	5.47 (3)
, dried, stewed	3.30 (1)	---	---	---
, juice from dried, stewed	3.30 (1)	---	---	---
Apricot nectar	---	1.56 (1)	---	---
Avocado	2.44 (1)	---	---	---
Banana	8.96 (2)	8.68 (2)	9.38 (1)	5.57 (3)
Cherries, red canned	---	---	---	0.00 (1)
, Royal Anne	2.20 (3)	---	---	---
, Royal Anne juice	2.43 (3)	---	3.65 (1)	---
Dates	0.00 (1)	---	---	---
Fruit cup	---	3.21 (4)	2.06 (3)	2.73 (2)
Fruit cup, juice	---	5.52 (3)	1.74 (1)	---
Fruit jello	---	---	---	1.96 (1)
Fruit juice mixture	25.77 (3)	13.02 (2)	---	15.41 (2)
Grapefruit, fresh	47.94 (2)	---	45.77 (4)	25.82 (3)
, juice	---	36.10 (1)	26.55 (2)	---
Grape juice	0.00 (1)	0.13 (2)	0.00 (3)	0.00 (5)
Grape and Apricot juice	---	0.00 (1)	0.87 (1)	---
Orange	66.20 (2)	---	63.56 (6)	59.19 (3)
Orange juice, canned	---	20.52 (1)	---	---
, fresh	---	40.08 (3)	---	---
Orange and grapefruit juice	---	22.10 (1)	---	---
Peaches, canned	3.33 (13)	4.24 (10)	3.55 (9)	4.56 (11)
, juice	3.53 (12)	3.86 (6)	---	2.95 (1)
, frozen	3.04 (1)	---	---	---

*The figures in the parentheses indicate the number of times the food was served and analyzed.

Table IV (continued)

Food	Snell Hall 1946-47 Mg %	Snell Hall 1947-48 Mg %	Memorial Union 1946-47 Mg %	Memorial Union 1947-48 Mg %
FRUITS (continued)				
Pears, canned	0.81 (7)	1.41 (4)	0.36 (7)	1.40 (8)
, juice	0.96 (5)	1.56 (1)	---	---
, fresh	---	---	---	2.16 (2)
Pineapple, canned	6.78 (5)	5.45 (4)	6.71 (5)	5.83 (6)
Prunes, canned	3.04 (6)	0.81 (1)	0.99 (4)	0.00 (2)
, juice	1.42 (6)	0.95 (1)	1.22 (2)	0.70 (3)
, dried, stewed	0.09 (2)	2.58 (8)	1.22 (2)	2.02 (5)
, juice from dried, stewed	0.00 (2)	1.04 (6)	---	---
Raisins and nuts	---	---	0.00 (1)	---
VEGETABLES:				
Asparagus, canned	---	14.81 (2)	---	---
Beans, canned kidney	---	3.91 (1)	0.87 (1)	---
Beans, canned string	0.43 (7)	0.13 (11)	0.64 (8)	0.08 (12)
Beets, canned	0.98 (6)	1.95 (5)	0.79 (8)	2.65 (10)
, pickled	---	0.65 (1)	---	---
Broccoli, fresh	1.91 (1)	54.47 (1)	---	---
Cabbage, cooked	---	11.23 (1)	26.96 (1)	24.91 (2)
, raw	---	70.80 (1)	---	---
Carrots, canned	---	0.00 (1)	---	---
, cooked	0.42 (5)	1.51 (3)	0.49 (8)	2.42 (6)
, raw	1.78 (7)	3.37 (4)	4.29 (6)	4.21 (4)
Carrots and peas	---	1.56 (1)	0.00 (2)	1.56 (1)
Cauliflower	61.38 (1)	---	45.94 (1)	36.63 (1)
Celery, cooked	---	---	0.96 (1)	---
, raw	8.56 (10)	6.93 (9)	5.30 (3)	5.95 (6)
Corn, canned	0.98 (4)	2.18 (8)	2.86 (10)	4.07 (6)
Corn pudding	---	2.12 (1)	---	---
Lettuce	2.07 (13)	0.96 (18)	1.53 (22)	1.25 (45)
Peas, canned	5.09 (9)	2.08 (6)	4.19 (9)	2.51 (10)
, frozen	8.86 (1)	2.85 (2)	2.40 (5)	4.99 (3)
Potatoes, Irish cooked	5.71 (16)	8.18 (12)	1.73 (24)	2.08 (26)
, sweet	14.50 (1)	28.00 (2)	15.15 (2)	15.62 (1)
Radishes	---	22.46 (1)	---	---
Spinach, canned	1.33 (3)	2.17 (1)	1.88 (3)	---
, fresh	---	11.63 (1)	---	8.94 (1)
Squash	4.39 (4)	0.00 (1)	9.61 (1)	---
Succotash	---	0.00 (1)	---	---
Tomato, canned	---	---	20.85 (2)	7.65 (1)
, fresh	---	21.08 (2)	16.17 (4)	12.09 (4)

Table IV (continued)

Food	Snell Hall 1946-47 Mg %	Snell Hall 1947-48 Mg %	Memorial Union 1946-47 Mg %	Memorial Union 1947-48 Mg %
VEGETABLES (continued)				
Tomato juice	27.78 (1)	19.91 (1)	26.57 (1)	---
Vegetables, mixed	---	2.52 (1)	---	0.64 (3)
MEAT MIXTURES AND SUBSTITUTES:				
Baked beans	---	---	0.48 (2)	2.39 (3)
Baked beans with tomato sauce	0.00 (1)	---	2.44 (1)	---
Beef hash	---	0.00 (2)	0.00 (1)	0.00 (1)
Beef with noodles	---	0.00 (1)	---	0.00 (1)
Beef stew	---	5.09 (3)	1.84 (3)	0.00 (3)
Bread dressing	0.00 (3)	0.00 (2)	---	---
Chili, canned	---	---	0.00 (1)	0.98 (1)
Eggs, scrambled	0.96 (1)	---	0.00 (2)	---
Ham, peas and corn	---	0.00 (1)	---	---
Kidney beans with bacon	---	---	---	0.65 (1)
Liver, fried	25.68 (1)	---	---	---
Meat with corn	0.00 (1)	---	---	---
Meat loaf	2.49 (2)	1.14 (1)	---	---
Meat pie	---	---	0.00 (1)	---
Meat salad	0.57 (2)	---	---	---
Meat spread	0.00 (1)	---	---	---
Rice and tomatoes	---	1.39 (1)	---	---
Salmon loaf	0.00 (1)	---	0.00 (1)	0.00 (1)
Spaghetti	0.00 (1)	---	---	0.61 (2)
Spaghetti with tomato	---	---	5.05 (1)	---
DAIRY PRODUCTS:				
Cheese, cottage	0.00 (4)	0.07 (4)	0.00 (3)	0.00 (1)
Chocolate, hot	---	0.00 (1)	---	---
Cocoa	0.00 (3)	---	---	---
Cream	0.21 (5)	0.06 (9)	0.00 (1)	0.00 (30)
Cream, whipped	0.10 (6)	0.09 (1)	0.00 (2)	0.01 (8)
Milk	0.46 (28)	0.24 (30)	0.27 (29)	0.00 (30)
DESSERTS:				
Apple crisp	0.00 (1)	---	---	---
Cake, white with orange glaze	---	---	3.58 (1)	---

Table IV (continued)

Food	Snell Hall 1946-47 Mg %	Snell Hall 1947-48 Mg %	Memorial Union 1946-47 Mg %	Memorial Union 1947-48 Mg %
DESSERTS (continued)				
Cherry Cobbler	0.00 (1)	---	---	0.00 (1)
Cherry roll	---	0.00 (1)	---	---
Custard, baked	0.00 (1)	---	---	---
, pumpkin	---	---	---	0.00 (1)
Date Torte	---	0.00 (1)	---	---
Peach crisp	1.95 (1)	---	---	---
Peach cobbler	0.00 (1)	---	---	---
Ice cream:				
Apricot	0.00 (1)	---	---	---
Berry	---	0.35 (1)	---	---
Butterscotch ribbon	---	---	---	0.00 (1)
Caramel ribbon	---	---	---	0.00 (1)
Chocolate	0.43 (1)	0.24 (4)	---	0.00 (1)
Chocolate ribbon	---	---	0.04 (7)	0.00 (3)
Peppermint	0.52 (1)	---	---	---
Raspberry ribbon	---	---	0.07 (4)	---
Strawberry	---	0.09 (1)	---	---
Vanilla	0.26 (8)	0.42 (7)	0.00 (1)	0.00 (5)
Jello:				
with apricots	---	1.74 (1)	---	---
with bananas	---	---	1.65 (1)	---
with blackberries	2.28 (1)	---	---	---
with mixed fruit	---	0.00 (1)	---	3.34 (2)
with oranges	12.16 (1)	---	---	---
with peach and pear	---	1.65 (1)	---	---
with peaches	---	---	1.56 (1)	---
with pears	---	1.31 (2)	---	---
with pineapple	---	---	2.64 (3)	2.34 (1)
Pie Filling:				
Apple	---	0.00 (2)	0.35 (3)	0.00 (1)
Apricot	---	---	2.52 (1)	---
Banana cream	---	---	---	0.00 (1)
Cherry	---	---	---	0.00 (1)
Mince	---	---	0.87 (1)	---
Peach	---	---	---	2.26 (1)
Pumpkin	---	---	0.09 (2)	---
Puddings:				
Banana	---	---	---	0.00 (1)
Banana-Butterscotch	---	---	---	0.00 (1)

Table IV (continued)

Food	Snell Hall 1946-47 Mg %	Snell Hall 1947-48 Mg %	Memorial Union 1946-47 Mg %	Memorial Union 1947-48 Mg %
DESSERTS (continued)				
Puddings (continued)				
Blanc Mange	1.74 (1)	---	0.00 (2)	---
Butterscotch	---	---	---	0.00 (1)
Chocolate	0.00 (2)	---	1.32 (2)	---
Rice with raisins	---	---	---	0.00 (1)
Pineapple upside down cake	1.30 (1)	---	---	0.00 (1)
Washington Cream Pie	---	---	---	0.00 (2)
SOUPS:				
Clam chowder	---	---	1.39 (2)	---
Split pea	---	0.83 (2)	---	1.46 (1)
Turkey noodle	0.00 (2)	---	---	---
Vegetable	0.38 (3)	1.80 (3)	2.38 (3)	---
SALADS:				
Apple	3.09 (2)	4.21 (2)	2.98 (4)	1.65 (4)
Cabbage slaw	32.89 (1)	34.83 (1)	---	54.42 (1)
Carrot and celery	---	2.43 (1)	---	---
Carrot and date	0.00 (1)	---	---	---
Carrot and raisin	---	0.87 (2)	---	---
Carrot, string bean and asparagus	---	---	---	1.04 (1)
Fruit, mixed	2.56 (2)	---	---	---
Gelatin-cottage cheese	---	0.00 (1)	---	---
Gelatin-fruit mixed	---	1.39 (1)	---	---
Gelatin-pineapple	---	---	2.95 (1)	---
Gelatin-pineapple and carrot	---	0.00 (1)	---	---
Gelatin-vegetable	1.26 (2)	---	---	---
Halibut, egg and celery	---	1.74 (1)	---	---
Ham	---	0.00 (1)	---	---
Macaroni	---	0.16 (1)	---	0.95 (1)
Potato	---	5.70 (1)	0.00 (1)	0.00 (1)
Turkey	---	1.13 (2)	---	---
Vegetable and chicken	---	0.87 (1)	---	---
Vegetable, mixed	3.24 (10)	2.02 (4)	26.01 (7)	30.76 (1)
Waldorf	---	1.56 (1)	---	---

Table IV (continued)

Food	Snell Hall 1946-47 Mg %	Snell Hall 1947-48 Mg %	Memorial Union 1946-47 Mg %	Memorial Union 1947-48 Mg %
PICKLES, RELISHES AND DRESSINGS, ETC.:				
Catsup	14.92 (1)	---	22.60 (3)	15.62 (1)
French dressing	---	---	---	0.17 (5)
Maple syrup	---	0.00 (1)	---	---
Mayonnaise with parsley	---	---	0.00 (1)	---
Mustard	---	---	2.43 (1)	3.47 (1)
Mustard and horseradish	---	4.25 (1)	---	---
Olives stuffed	0.00 (3)	---	---	---
Potato chips	32.42 (1)	---	24.11 (1)	---
Pickles, sweet	---	0.00 (3)	0.13 (2)	0.00 (1)
Salad dressing	1.83 (4)	0.18 (2)	---	1.97 (3)
Tartar sauce	---	---	0.35 (1)	0.00 (1)
Tomato sauce	---	9.77 (1)	---	16.84 (1)
Toppings (for ice cream, etc.)				
Apricot	---	2.43 (2)	---	---
Cherry	---	1.48 (1)	---	---
Chocolate	3.39 (1)	---	---	---
Marshmallow	---	0.00 (2)	---	---
Marshmallow with apples	---	0.61 (1)	---	---
JAMS AND SPREADS:				
Jam, Apricot	---	0.45 (5)	0.78 (3)	0.31 (2)
, Apricot and pineapple	---	0.65 (11)	---	0.16 (5)
, Berry	0.94 (4)	---	3.01 (7)	2.16 (7)
, Berry and apple	---	---	---	0.00 (1)
, Grape	---	---	---	0.82 (5)
, Loganberry	---	---	---	2.17 (1)
, Peach	---	---	---	0.26 (3)
, Peach-apricot	---	---	---	0.09 (1)
, Red raspberry	6.19 (1)	---	---	---
Honey	0.48 (2)	---	---	---
Peach butter	1.09 (2)	---	---	---
Peanut butter	---	4.60 (1)	---	0.00 (1)
Peanut butter and apricot jam	---	3.65 (1)	---	---

Table V - A

Total Daily Intake of Ascorbic Acid and Daily Plasma Ascorbic Acid Values for Adolescent Girls During Four Consecutive Experimental Periods in 1946-47

Date	M.G.		W.H.		B.R.		P.S.	
	Ascorbic Acid		Ascorbic Acid		Ascorbic Acid		Ascorbic Acid	
'47	Intake	Plasma	Intake	Plasma	Intake	Plasma	Intake	Plasma
	mg	mg %	mg	mg %	mg	mg %	mg	mg %
Usual Diet Period								
1-12	47	1.33	47	0.76	54	1.09	48	1.09
1-13	92	1.15	93	0.60	76	0.90	86	1.01
1-14	71	1.01	70	0.76	71	1.25	69	1.24
1-15	46	1.09	47	0.56	47	1.07	45	1.10
1-16	17	0.82	28	0.78	30	1.04	16	1.09
1-17	63	0.87	71	0.53	67	0.81	71	1.04
1-18	112	0.67	175	0.20	200	0.83	187	0.79
1-19		1.14		0.67		1.02		1.26
For entire first period:								
Mean	64	1.01	76	0.61	78	1.00	75	1.08
Av. Dev.*	±24	±0.17	±33	±0.14	±35	±0.12	±36	±0.10
Range	17-112	0.67-1.33	28-175	0.20-0.78	30-200	0.81-1.25	16-187	0.79-1.26

*Average deviation from the mean.

Table V - A (continued)

Date	M.G.		W.H.		B.R.		P.S.	
	Ascorbic Acid		Ascorbic Acid		Ascorbic Acid		Ascorbic Acid	
'47	Intake	Plasma	Intake	Plasma	Intake	Plasma	Intake	Plasma
	mg	mg %	mg	mg %	mg	mg %	mg	mg %
Saturation Period								
1-19	226		226		226		226	
1-20	210	1.13	210	0.82	210	1.17	210	1.36
1-21	216	1.27	216	1.12	216	1.19	216	1.25
1-22	221	1.13	221	1.06	221	1.13	221	1.28
1-23	216	1.19	216	1.20	216	1.24	216	1.17
1-24	218	1.14	218	1.01	218	1.07	218	1.13
1-25	225	1.04	225	1.00	225	1.17	225	1.29
1-26		1.13		1.30		1.14		1.20
Intake for entire period:								
Mean	219		219		219		219	
Av. Dev.	± 4		± 4		± 4		± 4	
Range	210-226		210-226		210-226		210-226	
Plasma for last five days of period:								
Mean		1.13		1.11		1.15		1.21
Av. Dev.		± 0.03		± 0.11		± 0.04		± 0.06
Range		1.04-1.19		1.00-1.30		1.07-1.24		1.13-1.29

Table V - A (continued)

Date '47	M.G. Ascorbic Acid Intake mg	M.G. Ascorbic Acid Plasma mg %	W.H. Ascorbic Acid Intake mg	W.H. Ascorbic Acid Plasma mg %	B.R. Ascorbic Acid Intake mg	B.R. Ascorbic Acid Plasma mg %	P.S. Ascorbic Acid Intake mg	P.S. Ascorbic Acid Plasma mg %
National Research Council Recommended Allowance								
1-26	80		80		80		80	
1-27	80	0.98	80	0.66	80	1.02	80	0.87
1-28	80	1.01	80	0.90	80	0.90	80	0.87
1-29	78	1.15	78	1.00	78	0.93	78	1.08
1-30	80	0.96	80	0.99	80	1.00	80	1.16
1-31	80	1.09	80	1.06	80	0.99	80	1.15
2- 1	99[1]	0.88	101	0.80	95	0.93	82	1.10
2- 2		0.89		0.97		0.99		0.87
Intake for entire period:								
Mean	82		83		82		80	
Av. Dev.	± 4		± 5		± 4		± 1	
Range	78-99		78-101		78-95		78-82	
Plasma for last five days of period:								
Mean		0.99		0.96		0.97		1.07
Av. Dev.		± 0.10		± 0.07		± 0.03		± 0.08
Range		0.88-1.15		0.80-1.06		0.93-1.00		0.87-1.16

[1]A mean intake of 80 mg of ascorbic acid had been the aim for this period, and this had been achieved except for the last day of the period when a high value for liver was obtained.

Table V - A (continued)

Date	M.G.		W.H.		B.R.		P.S.	
	Ascorbic Acid		Ascorbic Acid		Ascorbic Acid		Ascorbic Acid	
'47	Intake	Plasma	Intake	Plasma	Intake	Plasma	Intake	Plasma
	mg	mg %	mg	mg %	mg	mg %	mg	mg %
10 Mg Less Than National Research Council Recommended Allowance:								
2- 2	74		74		74		74	
2- 3	70	0.89	70	0.79	70	0.99	70	1.27
2- 4	70	0.80	70	0.89	70	0.91	70	1.14
2- 5	72	0.75	72	0.83	72	0.86	72	1.12
2- 6	74	0.78	74	0.76	74	0.87	74	1.09
2- 7	70	0.90	70	0.85	70	0.99	70	1.15
2- 8	70	0.92	70	0.72	70	0.99	70	0.96
2- 9		0.93		0.86		0.89		0.86
Intake for entire period:								
Mean	71		71		71		71	
Av. Dev.	± 2		± 2		± 2		± 2	
Range	70-74		70-74		70-74		70-74	
Plasma for last five days of period:								
Mean		0.86		0.80		0.92		1.04
Av. Dev.		± 0.07		± 0.05		± 0.06		± 0.10
Range		0.75-0.93		0.72-0.86		0.86-0.99		0.86-1.15

Table V - B

Total Daily Intake of Ascorbic Acid and Daily Plasma Ascorbic Acid Values
for Adolescent Girls During Three Consecutive Experimental Periods in 1947-48

Date	N.A.		B.D.		M.F.		R.R.	
	Ascorbic Acid		Ascorbic Acid		Ascorbic Acid		Ascorbic Acid	
'47	Intake	Plasma	Intake	Plasma	Intake	Plasma	Intake	Plasma
	mg	mg %	mg	mg %	mg	mg %	mg	mg %
Saturation Period								
10-18	268	1.12	268	1.24	268	0.76	268	0.87
10-19	274	1.01	274	1.29	274	1.05	274	1.29
10-20	243	1.05	243	1.13	243	1.28	243	1.15
10-21	250	1.07	250	1.25	250	1.25	250	1.19
10-22	270	1.00	270	1.13	270	1.27	270	0.94
10-23	261	1.03	261	1.09	261	1.13	261	1.28
10-24	252	0.90	252	1.23	252	1.10	252	1.27
10-25	256	1.07	256	1.29	256	1.35	256	1.17
10-26	249	0.98	249	1.17	249	1.19	249	1.40
10-27	289	1.07	289	1.12	289	1.25	289	1.22
10-28		1.10		1.13		1.42		1.30
Intake for entire period:								
Mean	261		261		261		261	
Av. Dev.	±11		±11		±11		±11	
Range	243-289		243-289		243-289		243-289	
Plasma for last eight days of period:								
Mean		1.03		1.18		1.25		1.22
Av. Dev.		± 0.05		± 0.07		± 0.12		± 0.12
Range		0.90-1.10		1.09-1.29		1.10-1.42		0.94-1.40
Plasma for last five days of period:								
Mean		1.02		1.19		1.26		1.27
Av. Dev.		± 0.07		± 0.06		± 0.10		± 0.06
Range		0.90-1.10		1.12-1.29		1.10-1.42		1.17-1.40

Table V - B (continued)

Total Daily Intake of Ascorbic Acid and Daily Plasma Ascorbic Acid Values
for Adolescent Girls During Three Consecutive Experimental Periods in 1947-48

Date	N.A.		B.D.		M.F.		R.R.	
	Ascorbic Acid		Ascorbic Acid		Ascorbic Acid		Ascorbic Acid	
'47	Intake	Plasma	Intake	Plasma	Intake	Plasma	Intake	Plasma
	mg	mg %	mg	mg %	mg	mg %	mg	mg %
National Research Council Recommended Allowance:								
10-28	81		81		81		81	
10-29	78	0.79	78	1.04	78	1.19	78	1.11
10-30	80	0.73	80	0.97	80	1.12	80	1.01
10-31	80	0.85	80	0.87	80	1.05	80	1.09
11- 1	80	0.85	80	0.84	80	0.90	80	1.01
11- 2	80	0.93	80	0.87	80	0.87	80	1.00
11- 3	80	0.89	80	0.94	80	1.01	80	1.05
11- 4	80	0.94	80	0.78	80	0.96	80	1.09
11- 5	80	0.85	80	0.90	80	0.96	80	1.01
11- 6	81	0.73	81	0.98	81	0.93	81	0.98
11- 7		0.74		0.88		1.04		0.99
Intake for entire period:								
Mean	80		80		80		80	
Av. Dev.	± 0.4		± 0.4		± 0.4		± 0.4	
Range	78-81		78-81		78-81		78-81	
Plasma for last eight days of period:								
Mean		0.85		0.88		0.97		1.03
Av. Dev.		± 0.07		± 0.06		± 0.08		± 0.04
Range		0.73-0.94		0.78-0.98		0.87-1.05		0.98-1.09
Plasma for last five days of period:								
Mean		0.83		0.90		0.98		1.02
Av. Dev.		± 0.08		± 0.05		± 0.04		± 0.04
Range		0.73-0.94		0.78-0.98		0.93-1.04		0.98-1.09

Table V - B (continued)

Total Daily Intake of Ascorbic Acid and Daily Plasma Ascorbic Acid Values
for Adolescent Girls During Three Consecutive Experimental Periods in 1947-48

Date	N.A.		B.D.		M.F.		R.R.	
	Ascorbic Acid		Ascorbic Acid		Ascorbic Acid		Ascorbic Acid	
'47	Intake	Plasma	Intake	Plasma	Intake	Plasma	Intake	Plasma
	mg	mg %	mg	mg %	mg	mg %	mg	mg %
10 Mg Less Than National Research Council Recommended Allowance:								
11- 7	70		70		70		70	
11- 8	70	0.84	70	0.83	70	0.93	70	0.84
11- 9	70	0.92	70	0.96	70	0.95	70	1.00
11-10	72	0.87	72	0.89	72	1.01	72	0.97
11-11	69	0.69	69	0.77	69	0.95	69	0.96
11-12	70	0.81	70	0.86	70	0.93	70	0.99
11-13	70	0.84	70	1.00	70	0.99	70	0.96
11-14	70	0.72	70	0.82	70	0.96	70	0.94
11-15	70	0.82	70	0.96	70	0.99	70	0.96
11-16	70	0.85	70	0.97	70	0.94	70	1.03
11-17		0.86		1.02		0.94		1.04
Intake for entire period:								
Mean	70		70		70		70	
Av. Dev.	± 0.3		± 0.3		± 0.3		± 0.3	
Range	69-72		69-72		69-72		69-72	
Plasma for last eight days of period:								
Mean		0.81		0.91		0.96		0.98
Av. Dev.		± 0.05		± 0.07		± 0.02		± 0.04
Range		0.69-0.87		0.77-1.02		0.93-1.01		0.94-1.04
Plasma for last five days of period:								
Mean		0.82		0.95		0.96		0.99
Av. Dev.		± 0.04		± 0.06		± 0.02		± 0.04
Range		0.72-0.86		0.82-1.02		0.94-0.99		0.94-1.04

Table V - C

Total Daily Intake of Ascorbic Acid and Daily Plasma Ascorbic Acid Values for Adolescent Boys During Four Consecutive Experimental Periods in 1946-47

Date	J.C.		V.D.		J.J.		G.S.	
	Ascorbic Acid		Ascorbic Acid		Ascorbic Acid		Ascorbic Acid	
'47	Intake	Plasma	Intake	Plasma	Intake	Plasma	Intake	Plasma
	mg	mg %	mg	mg %	mg	mg %	mg	mg %
Usual Diet Period								
2-15	128	0.80	77	0.18	91	0.38	153	0.39
2-16	100	0.77	113	0.36	111	0.33	111	0.47
2-17	144	0.69	119	0.23	80	0.42	178	0.46
2-18	138	0.82	129	0.36	124	0.44	128	0.62
2-19	159	0.92	296	0.39	164	0.38	198	0.64
2-20	22	0.85	21	0.55	24	0.45	21	0.75
2-21	118	0.66	154	0.38	122	0.37	122	0.64
2-22		0.69		0.66		0.34		0.89
For entire period:								
Mean	116	0.78	130	0.39	102	0.39	130	0.61
Av. Dev.	±31	±0.07	±54	±0.11	±32	± 0.04	± 40	± 0.13
Range	22-159	0.66-0.92	21-296	0.18-0.66	24-164	0.33-0.45	21-198	0.39-0.89

Table V - C (continued)

Date '47	J.C. Ascorbic Acid Intake mg	J.C. Ascorbic Acid Plasma mg %	V.D. Ascorbic Acid Intake mg	V.D. Ascorbic Acid Plasma mg %	J.J. Ascorbic Acid Intake mg	J.J. Ascorbic Acid Plasma mg %	G.S. Ascorbic Acid Intake mg	G.S. Ascorbic Acid Plasma mg %
Saturation Period								
2-22	264		289		296		294	
2-23	260	0.81	264	0.76	266	0.50	263	0.94
2-24	351	0.95	353	0.88	291	0.57	283	1.03
2-25	292	0.93	421	0.99	352	0.68	355	1.10
2-26	301	0.99	281	0.92	290	0.85	290	1.06
2-27	413	1.24	407	0.89	421	0.96	424	1.00
2-28	352	1.16	486	1.03	373	1.12	357	1.07
3- 1		1.05		1.22		0.91		1.13
Intake for entire period:								
Mean	319		357		327		324	
Av. Dev.	± 45		± 69		± 47		± 47	
Range	260-413		264-486		266-421		263-424	
Plasma for last five days of period:								
Mean		1.07		1.01		0.90		1.07
Av. Dev.		± 0.10		± 0.09		± 0.11		± 0.03
Range		0.93-1.24		0.89-1.22		0.68-1.12		1.00-1.13

Table V - C (continued)

Date	J.C.		V.D.		J.J.		G.S.	
	Ascorbic Acid		Ascorbic Acid		Ascorbic Acid		Ascorbic Acid	
'47	Intake	Plasma	Intake	Plasma	Intake	Plasma	Intake	Plasma
	mg	mg %	mg	mg %	mg	mg %	mg	mg %
National Research Council Recommended Allowance								
3- 1	102		102		102		102	
3- 2	101	1.04	101	0.85	101	1.07	101	0.95
3- 3	100	0.86	100	0.87	100	0.99	100	0.78
3- 4	100	0.98	100	0.82	100	1.02	100	0.95
3- 5	100	0.88	100	0.85	100	0.86	100	0.86
3- 6	100	0.82	100	0.72	100	0.86	100	0.86
3- 7	100	0.89	100	0.84	100	0.90	100	0.86
3- 8		0.99		0.85		0.84		0.77
Intake for entire period:								
Mean	100		100		100		100	
Av. Dev.	± 0		± 0		± 0		± 0	
Range	100-102		100-102		100-102		100-102	
Plasma for last five days of period:								
Mean		0.91		0.82		0.90		0.86
Av. Dev.		± 0.06		± 0.04		± 0.05		± 0.04
Range		0.82-0.99		0.72-0.85		0.84-1.02		0.77-0.95

Table V - C (continued)

Date	J.C.		V.D.		J.J.		G.S.	
	Ascorbic Acid		Ascorbic Acid		Ascorbic Acid		Ascorbic Acid	
'47	Intake	Plasma	Intake	Plasma	Intake	Plasma	Intake	Plasma
	mg	mg %	mg	mg %	mg	mg %	mg	mg %
10 Mg Less Than National Research Council Recommended Allowance:								
3- 8	90		90		90		90	
3- 9	105	0.87	105	0.93	105	0.83	105	0.84
3-10	90	0.84	90	0.67	90	0.93	90	0.83
3-11	91	0.86	91	0.69	91	0.96	91	0.94
3-12	90	0.82	90	0.88	90	0.75	90	0.79
3-13	90	0.81	90	0.68	90	0.69	90	0.82
3-14	90	0.84	90	0.72	90	0.79	90	0.81
3-15		0.63		0.79		0.81		0.84
Intake for entire period:								
Mean	92		92		92		92	
Av. Dev.	± 3		± 3		± 3		± 3	
Range	90-105		90-105		90-105		90-105	
Plasma for last five days of period:								
Mean		0.79		0.75		0.80		0.84
Av. Dev.		± 0.07		± 0.07		± 0.07		± 0.04
Range		0.63-0.86		0.68-0.88		0.69-0.96		0.79-0.94

Table V - D

Total Daily Intake of Ascorbic Acid and Daily Plasma Ascorbic Acid Values
for Adolescent Boys During Three Consecutive Experimental Periods in 1947-48

Date	T.C.		D.E.		W.P.		D.R.	
	Ascorbic Acid		Ascorbic Acid		Ascorbic Acid		Ascorbic Acid	
'48	Intake	Plasma	Intake	Plasma	Intake	Plasma	Intake	Plasma
	mg	mg %	mg	mg %	mg	mg %	mg	mg %
Saturation Period								
1-31	297	0.21	291	0.34	294	0.85	298	0.48
2- 1	245	0.25	247	0.29	245	0.95	244	0.67
2- 2	251	0.27	247	0.36	250	1.03	246	0.93
2- 3	305	0.39	306	0.38	318	0.99	280	0.87
2- 4	247	0.46	240	0.43	244	1.18	244	1.00
2- 5	299	0.54	320	0.48	299	1.12	298	1.03
2- 6	274	0.63	253	0.63	260	1.06	268	1.07
2- 7	246	0.87	246	0.92	246	0.99	246	1.15
2- 8	243	1.14	243	0.89	243	1.32	243	0.94
2- 9	311	1.02	309	0.90	305	1.08	285	1.09
2-10		1.31		1.06		1.16		1.18
Intake for entire period:								
Mean	272		270		270		265	
Av. Dev.	± 25		± 29		± 27		± 21	
Range	243-311		240-320		243-318		243-298	
Plasma for last eight days of period:								
Mean		0.80		0.71		1.11		1.04
Av. Dev.		± 0.44		± 0.32		± 0.11		± 0.17
Range		0.39-1.31		0.38-1.06		0.99-1.32		0.87-1.18
Plasma for last five days of period:								
Mean		0.99		0.88		1.12		1.09
Av. Dev.		± 0.20		± 0.10		± 0.09		± 0.06
Range		0.63-1.31		0.63-1.06		0.99-1.32		0.94-1.18

Table V - D (continued)

Total Daily Intake of Ascorbic Acid and Daily Plasma Ascorbic Acid Values
for Adolescent Boys During Three Consecutive Experimental Periods in 1947-48

Date	T.C.		D.E.		W.P.		D.R.	
	Ascorbic Acid		Ascorbic Acid		Ascorbic Acid		Ascorbic Acid	
'48	Intake	Plasma	Intake	Plasma	Intake	Plasma	Intake	Plasma
	mg	mg %	mg	mg %	mg	mg %	mg	mg %
National Research Council Recommended Allowance:								
2-10	99		99		99		99	
2-11	101	1.11	101	1.07	101	1.08	101	0.96
2-12	99	1.07	99	0.88	99	0.99	99	0.93
2-13	100	0.96	100	0.66	100	0.74	100	0.69
2-14	100	0.87	100	0.69	100	0.76	100	0.84
2-15	100	0.90	100	0.77	100	0.72	100	0.83
2-16	99	0.84	99	0.72	99	0.85	99	0.72
2-17	100	0.91	100	0.66	100	0.78	100	0.64
2-18	100	0.91	100	0.74	100	0.85	100	0.70
2-19	100	0.91	100	0.63	100	0.75	100	0.70
2-20		0.91		0.62		0.84		0.71
Intake for entire period:								
Mean	100		100		100		100	
Av. Dev.	± 0.4		± 0.4		± 0.4		± 0.4	
Range	99-101		99-101		99-101		99-101	
Plasma for last eight days of period:								
Mean		0.90		0.69		0.79		0.73
Av. Dev.		± 0.06		± 0.10		± 0.09		± 0.09
Range		0.84-0.96		0.62-0.77		0.72-0.85		0.64-0.84
Plasma for last five days of period:								
Mean		0.90		0.67		0.81		0.69
Av. Dev.		± 0.02		± 0.04		± 0.04		± 0.02
Range		0.84-0.91		0.62-0.74		0.75-0.85		0.64-0.72

Table V - D (continued)

Total Daily Intake of Ascorbic Acid and Daily Plasma Ascorbic Acid Values
for Adolescent Boys During Three Consecutive Experimental Periods in 1947-48

Date	T.C.		D.E.		W.P.		D.R.	
	Ascorbic Acid		Ascorbic Acid		Ascorbic Acid		Ascorbic Acid	
'48	Intake	Plasma	Intake	Plasma	Intake	Plasma	Intake	Plasma
	mg	mg %	mg	mg %	mg	mg %	mg	mg %
10 Mg Less Than National Research Council Recommended Allowance:								
2-20	90		90		90		90	
2-21	90	1.04	90	0.76	90	0.92	90	0.83
2-22	90	0.96	90	0.70	90	0.69	90	0.82
2-23	92	0.93	92	0.61	92	0.72	92	0.68
2-24	90	0.73	90	0.67	90	0.62	90	0.59
2-25	87	0.69	87	0.71	87	0.73	87	0.89
2-26	91	0.85	91	0.67	91	0.69	91	0.75
2-27	90	0.76	90	0.66	90	0.71	90	0.83
2-28	90	0.93	90	0.71	90	0.69	90	0.83
2-29	90	0.85	90	0.65	90	0.88	90	0.59
3- 1		0.79		0.70		0.71		0.68
Intake for entire period:								
Mean	90		90		90		90	
Av. Dev.	± 0.6		± 0.6		± 0.6		± 0.6	
Range	87-92		87-92		87-92		87-92	
Plasma for last eight days of period:								
Mean		0.82		0.67		0.72		0.73
Av. Dev.		± 0.09		± 0.03		± 0.07		± 0.09
Range		0.69-0.93		0.61-0.71		0.62-0.88		0.59-0.89
Plasma for last five days of period:								
Mean		0.84		0.68		0.74		0.74
Av. Dev.		± 0.05		± 0.02		± 0.06		± 0.08
Range		0.76-0.93		0.65-0.71		0.69-0.88		0.59-0.83

Table VI

Significance of Differences Between the Means for the Concentration of Ascorbic Acid in the Plasma

1946-47	M.G.			W.H.			B.R.			P.S.		
Sat'n.	x	d	d^2	x	d	d^2	x	d	d^2	x	d	d^2
Date												
1-22	1.13	0.00	.0000	1.06	-0.05	.0025	1.13	-0.02	.0004	1.28	+0.07	.0049
1-23	1.19	+0.06	.0036	1.20	+0.09	.0081	1.24	+0.09	.0081	1.17	-0.04	.0016
1-24	1.14	+0.01	.0001	1.01	-0.10	.0100	1.07	-0.08	.0064	1.13	-0.08	.0064
1-25	1.04	-0.09	.0081	1.00	-0.11	.0121	1.17	+0.02	.0004	1.29	+0.08	.0064
1-26	1.13	0.00	.0000	1.30	+0.19	.0361	1.14	-0.01	.0001	1.20	-0.01	.0001
	1.13	±0.03	.0118	1.11	±0.11	.0688	1.15	±0.04	.0154	1.21	±0.06	.0194

$\sigma_{M_1} = \pm\sqrt{\frac{0.0118}{20}} = \pm\sqrt{0.00059} = \pm\ 0.0242$

$\sigma_{M_1} = \pm\sqrt{\frac{0.0688}{20}} = \pm\sqrt{0.00344} = \pm\ 0.0586$

$\sigma_{M_1} = \pm\sqrt{\frac{0.0154}{20}} = \pm\sqrt{0.00077} = \pm\ 0.0277$

$\sigma_{M_1} = \pm\sqrt{\frac{0.0194}{20}} = \pm\sqrt{0.00097} = \pm\ 0.0311$

N.R.C.												
Date												
1-29	1.15	+0.16	.0256	1.00	+0.04	.0016	0.93	-0.04	.0016	1.08	+0.01	.0001
1-30	0.96	-0.03	.0009	0.99	+0.03	.0009	1.00	+0.03	.0009	1.16	+0.09	.0081
1-31	1.09	+0.10	.0100	1.06	+0.10	.0100	0.99	+0.02	.0004	1.15	+0.08	.0064
2- 1	0.88	-0.11	.0121	0.80	-0.16	.0256	0.93	-0.04	.0016	1.10	+0.03	.0009
2- 2	0.89	-0.10	.0100	0.97	+0.01	.0001	0.99	+0.02	.0004	0.87	-0.20	.0400
	0.99	±0.10	.0586	0.96	±0.07	.0382	0.97	±0.03	.0049	1.07	±0.08	.0555

$\sigma_{M_2} = \pm\sqrt{\frac{0.0586}{20}} = \pm\sqrt{0.00293} = \pm\ 0.0541$

$\sigma_{M_2} = \pm\sqrt{\frac{0.0382}{20}} = \pm\sqrt{0.00191} = \pm\ 0.0437$

$\sigma_{M_2} = \pm\sqrt{\frac{0.0049}{20}} = \pm\sqrt{0.000245} = \pm\ 0.01565$

$\sigma_{M_2} = \pm\sqrt{\frac{0.0555}{20}} = \pm\sqrt{0.002775} = \pm\ 0.0526$

Table VI (continued)

1946-47	M.G.			W.H.			B.R.			P.S.		
N.R.C.-10 mg.	x	d	d^2	x	d	d^2	x	d	d^2	x	d	d^2
Date												
2- 5	0.75	-0.11	.0121	0.83	+0.03	.0009	0.86	-0.06	.0036	1.12	+0.08	.0064
2- 6	0.78	-0.08	.0064	0.76	-0.04	.0016	0.87	-0.05	.0025	1.09	+0.05	.0025
2- 7	0.90	+0.04	.0016	0.85	+0.05	.0025	0.99	+0.07	.0049	1.15	+0.11	.0121
2- 8	0.92	+0.06	.0036	0.72	-0.08	.0064	0.99	+0.07	.0049	0.96	-0.08	.0064
2- 9	0.93	+0.07	.0049	0.86	+0.06	.0036	0.89	-0.03	.0009	0.86	-0.18	.0324
	0.86	±0.07	.0286	0.80	±0.05	.0150	0.92	±0.06	.0168	1.04	±0.10	.0598

$\sigma_{M_3} = \pm\sqrt{\frac{0.0286}{20}}$ $\quad \sigma_{M_3} = \pm\sqrt{\frac{0.0150}{20}}$ $\quad \sigma_{M_3} = \pm\sqrt{\frac{0.0168}{20}}$ $\quad \sigma_{M_3} = \pm\sqrt{\frac{0.0598}{20}}$

$= \pm\sqrt{0.00143}$ $\quad = \pm\sqrt{0.00075}$ $\quad = \pm\sqrt{0.00084}$ $\quad = \pm\sqrt{0.00299}$

$= \pm\ 0.0378$ $\quad = \pm\ 0.0273$ $\quad = \pm\ 0.0289$ $\quad = \pm\ 0.05468$

$\sigma_{DM_1-M_2} = \pm\sqrt{.00059+.00293}$ $\quad \sigma_{DM_1-M_2} = \pm\sqrt{.00344+.00191}$ $\quad \sigma_{DM_1-M_2} = \pm\sqrt{.00077+.000245}$ $\quad \sigma_{DM_1-M_2} = \pm\sqrt{.00097+.002775}$

$\sigma_D = \pm\sqrt{.00352}$ $\quad \sigma_D = \pm\sqrt{.00535}$ $\quad \sigma_D = \pm\sqrt{.001015}$ $\quad \sigma_D = \pm\sqrt{.003745}$

$= \pm\ 0.0593$ $\quad = \pm\ 0.07314$ $\quad = \pm\ 0.03185$ $\quad = \pm\ 0.06119$

1.13 − 0.99 = 0.14* significant

1.11 − 0.96 = 0.15* significant

1.15 − 0.97 = 0.18* significant

1.21 − 1.07 = 0.14* significant

$\sigma_{DM_2-M_3} = \pm\sqrt{.00293+.00143}$ $\quad \sigma_{DM_2-M_3} = \pm\sqrt{.00191+.00075}$ $\quad \sigma_{DM_2-M_3} = \pm\sqrt{.000245+.00084}$ $\quad \sigma_{DM_2-M_3} = \pm\sqrt{.002775+.00299}$

$\sigma_D = \pm\sqrt{.00436}$ $\quad \sigma_D = \pm\sqrt{.00266}$ $\quad \sigma_D = \pm\sqrt{.001085}$ $\quad \sigma_D = \pm\sqrt{.005765}$

$= \pm\ 0.06603$ $\quad = \pm\ 0.05157$ $\quad = \pm\ 0.03293$ $\quad = \pm\ 0.07592$

0.99 − 0.86 = 0.13 significant

0.96 − 0.80 = 0.16 significant

0.97 − 0.92 = 0.05 not significant

1.07 − 1.04 = 0.03 not significant

*Differences are supposed to be two times the standard deviation of the differences to be significant.

Table VI (continued)

1946-47	M.G.	W.H.	B.R.	P.S.
	$\sigma_{DM_1-M_3} = \pm\sqrt{.00059+.00143}$	$\sigma_{DM_1-M_3} = \pm\sqrt{.00344+.00075}$	$\sigma_{DM_1-M_3} = \pm\sqrt{.00077+.00084}$	$\sigma_{DM_1-M_3} = \pm\sqrt{.00097+.00299}$
	$\sigma_D = \pm\sqrt{.00202}$	$\sigma_D = \pm\sqrt{.00419}$	$\sigma_D = \pm\sqrt{.00161}$	$\sigma_D = \pm\sqrt{.00396}$
	$= \pm 0.0449$	$= \pm 0.06473$	$= \pm 0.04012$	$= \pm 0.0629$
	1.13	1.11	1.15	1.21
	- 0.86	- 0.80	- 0.92	- 1.04
	0.27 significant	0.31 significant	0.23 significant	0.17 significant

Table VI (continued)

1947-48	Deviation calculated on last 8 days of each period											
	N.A.			B.D.			M.F.			R.R.		
Sat'n Date	x	d	d^2	x	d	d^2	x	d	d^2	x	d	d^2
10-21	1.07	+0.04	.0016	1.25	+0.07	.0049	1.25	0.00	.0000	1.19	-0.03	.0009
10-22	1.00	-0.03	.0009	1.13	-0.05	.0025	1.27	+0.02	.0004	0.94	-0.28	.0784
10-23	1.03	0.00	.0000	1.09	-0.09	.0081	1.13	-0.12	.0144	1.28	+0.06	.0036
10-24	0.90	-0.13	.0169	1.23	+0.05	.0025	1.10	-0.15	.0225	1.27	+0.05	.0025
10-25	1.07	+0.04	.0016	1.29	+0.11	.0121	1.35	+0.10	.0100	1.17	-0.05	.0025
10-26	0.98	-0.05	.0025	1.17	-0.01	.0001	1.19	-0.06	.0036	1.40	+0.18	.0324
10-27	1.07	+0.04	.0016	1.12	-0.06	.0036	1.25	0.00	.0000	1.22	0.00	.0000
10-28	1.10	+0.07	.0049	1.13	-0.05	.0025	1.42	+0.17	.0289	1.30	+0.08	.0064
	1.03	±0.05	.0300	1.18	±0.06	.0363	1.25	±0.08	.0798	1.22	±0.09	.1267
	$\sigma_{M_1} = \pm\sqrt{\frac{.0300}{56}}$			$\sigma_{M_1} = \pm\sqrt{\frac{.0363}{56}}$			$\sigma_{M_1} = \pm\sqrt{\frac{.0798}{56}}$			$\sigma_{M_1} = \pm\sqrt{\frac{.1267}{56}}$		
	$= \pm\sqrt{.000536}$			$= \pm\sqrt{.000648}$			$= \pm\sqrt{.001425}$			$= \pm\sqrt{.002263}$		
	$= \pm$ .02315			$= \pm$ .02545			$= \pm$ .037749			$= \pm$ .04757		
N.R.C. Date												
10-31	0.85	0.00	.0000	0.87	-0.01	.0001	1.05	+0.08	.0064	1.09	+0.06	.0036
11- 1	0.85	0.00	.0000	0.84	-0.04	.0016	0.90	-0.07	.0049	1.01	-0.02	.0004
11- 2	0.93	+0.08	.0064	0.87	-0.01	.0001	0.87	-0.10	.0100	1.00	-0.03	.0009
11- 3	0.89	+0.04	.0016	0.94	+0.06	.0036	1.01	+0.04	.0016	1.05	+0.02	.0004
11- 4	0.94	+0.09	.0081	0.78	-0.10	.0100	0.96	-0.01	.0001	1.09	+0.06	.0036
11- 5	0.85	0.00	.0000	0.90	+0.02	.0004	0.96	-0.01	.0001	1.01	-0.02	.0004
11- 6	0.73	-0.12	.0144	0.98	+0.10	.0100	0.93	-0.04	.0016	0.98	-0.05	.0025
11- 7	0.74	-0.11	.0121	0.88	0.00	.0000	1.04	+0.07	.0049	0.99	-0.04	.0016
	0.85	±0.06	.0426	0.88	±0.04	.0258	0.97	±0.05	.0296	1.03	±0.04	.0134
	$\sigma_{M_2} = \pm\sqrt{\frac{.0426}{56}}$			$\sigma_{M_2} = \pm\sqrt{\frac{.0258}{56}}$			$\sigma_{M_2} = \pm\sqrt{\frac{.0296}{56}}$			$\sigma_{M_2} = \pm\sqrt{\frac{.0134}{56}}$		
	$= \pm\sqrt{.000761}$			$= \pm\sqrt{.000461}$			$= \pm\sqrt{.000529}$			$= \pm\sqrt{.000239}$		
	$= \pm$ .02758			$= \pm$ .02147			$= \pm$ .023			$= \pm$ .01545		

Table VI (continued)

1947-48	Deviation calculated on last 8 days of each period											
	N.A.			B.D.			M.F.			R.R.		
N.R.C.-10 mg.	x	d	d^2	x	d	d^2	x	d	d^2	x	d	d^2
Date												
11-10	0.87	+0.06	.0036	0.89	-0.02	.0004	1.01	+0.05	.0025	0.97	-0.01	.0001
11-11	0.69	-0.12	.0144	0.77	-0.14	.0196	0.95	-0.01	.0001	0.96	-0.02	.0004
11-12	0.81	0.00	.0000	0.86	-0.05	.0025	0.93	-0.03	.0009	0.99	+0.01	.0001
11-13	0.84	+0.03	.0009	1.00	+0.09	.0081	0.99	+0.03	.0009	0.96	-0.02	.0004
11-14	0.72	-0.09	.0081	0.82	-0.09	.0081	0.96	0.00	.0000	0.94	-0.04	.0016
11-15	0.82	+0.01	.0001	0.96	+0.05	.0025	0.99	+0.03	.0009	0.96	-0.02	.0004
11-16	0.85	+0.04	.0016	0.97	+0.06	.0036	0.94	-0.02	.0004	1.03	+0.05	.0025
11-17	0.86	+0.05	.0025	1.02	+0.11	.0121	0.94	-0.02	.0004	1.04	+0.06	.0036
	0.81	±0.05	.0312	0.91	±0.08	.0569	0.96	±0.02	.0061	0.98	±0.03	.0091

$\sigma_{M_3} = \pm\sqrt{\frac{.0312}{56}}$ $= \pm\sqrt{.000557}$ $= \pm .0236$

$\sigma_{M_3} = \pm\sqrt{\frac{.0569}{56}}$ $= \pm\sqrt{.001016}$ $= \pm .03187$

$\sigma_{M_3} = \pm\sqrt{\frac{.0061}{56}}$ $= \pm\sqrt{.000109}$ $= \pm .010444$

$\sigma_{M_3} = \pm\sqrt{\frac{.0091}{56}}$ $= \pm\sqrt{.000163}$ $= \pm .01276$

$\sigma_{DM_1-M_2} = \pm\sqrt{.000536 + .000761}$

$\sigma_D = \pm\sqrt{.001297}$

$= \pm .03601$

$1.03 - 0.85 = 0.18$ significant

$\sigma_{DM_1-M_2} = \pm\sqrt{.000648 + .000461}$

$\sigma_D = \pm\sqrt{.001109}$

$= \pm .0333$

$1.18 - 0.88 = 0.30$ significant

$\sigma_{DM_1-M_2} = \pm\sqrt{.001425 + .000529}$

$\sigma_D = \pm\sqrt{.001954}$

$= \pm .0442$

$1.25 - 0.97 = 0.28$ significant

$\sigma_{DM_1-M_2} = \pm\sqrt{.002263 + .000239}$

$\sigma_D = \pm\sqrt{.002502}$

$= \pm .050019$

$1.22 - 1.03 = 0.19$ significant

Table VI (continued)

1947-48	N.A.	B.D.	M.F.	R.R.
	$\sigma_{DM_2-M_3}=\pm\sqrt{.000761+.000557}$	$\sigma_{DM_2-M_3}=\pm\sqrt{.000461+.001016}$	$\sigma_{DM_2-M_3}=\pm\sqrt{.000529+.000109}$	$\sigma_{DM_2-M_3}=\pm\sqrt{.000239+.000163}$
	$\sigma_D=\pm\sqrt{.001318}$	$\sigma_D=\pm\sqrt{.001477}$	$\sigma_D=\pm\sqrt{.000638}$	$\sigma_D=\pm\sqrt{.000402}$
	$=\pm$ .0363	$=\pm$ .03843	$=\pm$ .02525	$=\pm$ .02004
	0.85 - 0.81 not 0.04 significant	0.88 - 0.91 not -0.03 significant	0.97 - 0.96 not 0.01 significant	1.03 - 0.98 0.05 significant
	$\sigma_{DM_1-M_3}=\pm\sqrt{.000536+.000557}$	$\sigma_{DM_1-M_3}=\pm\sqrt{.000618+.001016}$	$\sigma_{DM_1-M_3}=\pm\sqrt{.001425+.000109}$	$\sigma_{DM_1-M_3}=\pm\sqrt{.002263+.000163}$
	$\sigma_D=\pm\sqrt{.001093}$	$\sigma_D=\pm\sqrt{.001634}$	$\sigma_D=\pm\sqrt{.001534}$	$\sigma_D=\pm\sqrt{.002426}$
	$=\pm$ .03306	$=\pm$ .04079	$=\pm$ .03916	$=\pm$ .04925
	1.03 - 0.81 0.22 significant	1.18 - 0.91 0.27 significant	1.25 - 0.96 0.29 significant	1.22 - 0.98 0.24 significant

Table VI (continued)

Deviation calculated on last 5 days of each period

1947-48	N.A.			B.D.			M.F.			R.h.		
Sat'n	x	d	d^2	x	d	d^2	x	d	d^2	x	d	d^2
Date												
10-24	0.90	-0.12	.0144	1.23	+0.04	.0016	1.10	-0.16	.0256	1.27	0.00	.0000
10-25	1.07	+0.05	.0025	1.29	+0.10	.0100	1.35	+0.09	.0081	1.17	-0.10	.0100
10-26	0.98	-0.04	.0016	1.17	-0.02	.0004	1.19	-0.07	.0049	1.40	+0.13	.0169
10-27	1.07	+0.05	.0025	1.12	-0.07	.0049	1.25	-0.01	.0001	1.22	-0.05	.0025
10-28	1.10	+0.08	.0064	1.13	-0.06	.0036	1.42	+0.16	.0256	1.30	+0.03	.0009
	1.02	±0.07	.0274	1.19	±0.06	.0205	1.26	±0.10	.0643	1.27	±0.06	.0303

$\sigma_{M_1} = \pm\sqrt{\frac{.0274}{20}}$ $\quad \sigma_{M_1} = \pm\sqrt{\frac{.0205}{20}}$ $\quad \sigma_{M_1} = \pm\sqrt{\frac{.0643}{20}}$ $\quad \sigma_{M_1} = \pm\sqrt{\frac{.0303}{20}}$

$= \pm\sqrt{.00137}$ $\quad = \pm\sqrt{.001025}$ $\quad = \pm\sqrt{.003215}$ $\quad = \pm\sqrt{.001515}$

$= \pm .0370$ $\quad = \pm .032015$ $\quad = \pm .0567$ $\quad = \pm .03892$

N.R.C.												
Date												
11- 3	0.89	+0.06	.0036	0.94	+0.04	.0016	1.01	+0.03	.0009	1.05	+0.03	.0009
11- 4	0.94	+0.11	.0121	0.78	-0.12	.0144	0.96	-0.02	.0004	1.09	+0.07	.0049
11- 5	0.85	+0.02	.0004	0.90	0.00	.0000	0.96	-0.02	.0004	1.01	-0.01	.0001
11- 6	0.73	-0.10	.0100	0.98	+0.08	.0064	0.93	-0.05	.0025	0.98	-0.04	.0016
11- 7	0.74	-0.09	.0081	0.88	-0.02	.0004	1.04	+0.06	.0036	0.99	-0.03	.0009
	0.83	±0.08	.0342	0.90	±0.05	.0228	0.98	±0.04	.0078	1.02	±0.04	.0084

$\sigma_{M_2} = \pm\sqrt{\frac{.0342}{20}}$ $\quad \sigma_{M_2} = \pm\sqrt{\frac{.0228}{20}}$ $\quad \sigma_{M_2} = \pm\sqrt{\frac{.0078}{20}}$ $\quad \sigma_{M_2} = \pm\sqrt{\frac{.0084}{20}}$

$= \pm\sqrt{.00171}$ $\quad = \pm\sqrt{.00114}$ $\quad = \pm\sqrt{.00039}$ $\quad = \pm\sqrt{.00042}$

$= \pm .04135$ $\quad = \pm .03376$ $\quad = \pm .01974$ $\quad = \pm .02049$

Table VI (continued)

1947-48	Deviation calculated on last 5 days of each period											
	N.A.			B.D.			M.F.			R.R.		
N.R.C.-10 mg.	x	d	d^2	x	d	d^2	x	d	d^2	x	d	d^2
Date												
11-13	0.84	+0.02	.0004	1.00	+0.05	.0025	0.99	+0.03	.0009	0.96	-0.03	.0009
11-14	0.72	-0.10	.0100	0.82	-0.13	.0169	0.96	0.00	.0000	0.94	-0.05	.0025
11-15	0.82	0.00	.0000	0.96	+0.01	.0001	0.99	+0.03	.0009	0.96	-0.03	.0009
11-16	0.85	+0.03	.0009	0.97	+0.02	.0004	0.94	-0.02	.0004	1.03	+0.04	.0016
11-17	0.86	+0.04	.0016	1.02	+0.07	.0049	0.94	-0.02	.0004	1.04	+0.05	.0025
	0.82	±0.04	.0129	0.95	±0.06	.0248	0.96	±0.02	.0026	0.99	±0.04	.0084

$\sigma_{M_3} = \pm\sqrt{\frac{.0129}{20}}$ $\quad \sigma_{M_3} = \pm\sqrt{\frac{.0248}{20}}$ $\quad \sigma_{M_3} = \pm\sqrt{\frac{.0026}{20}}$ $\quad \sigma_{M_3} = \pm\sqrt{\frac{.0084}{20}}$

$= \pm\sqrt{.000645}$ $\quad = \pm\sqrt{.00124}$ $\quad = \pm\sqrt{.00013}$ $\quad = \pm\sqrt{.00042}$

$= \pm .02539$ $\quad = \pm .0352$ $\quad = \pm .0114$ $\quad = \pm .0204$

$\sigma_{DM_1-M_2} = \pm\sqrt{.00137+.00171}$ $\quad \sigma_{DM_1-M_2} = \pm\sqrt{.001025+.00114}$ $\quad \sigma_{DM_1-M_2} = \pm\sqrt{.003215+.00039}$ $\quad \sigma_{DM_1-M_2} = \pm\sqrt{.001515+.00042}$

$\sigma_D = \pm\sqrt{.00308}$ $\quad \sigma_D = \pm\sqrt{.002165}$ $\quad \sigma_D = \pm\sqrt{.003605}$ $\quad \sigma_D = \pm\sqrt{.001935}$

$= \pm .05549$ $\quad = \pm .046529$ $\quad = \pm .06004$ $\quad = \pm .043988$

1.02 − 0.83 = 0.19 significant

1.19 − 0.90 = 0.29 significant

1.26 − 0.98 = 0.28 significant

1.27 − 1.02 = 0.25 significant

$\sigma_{DM_2-M_3} = \pm\sqrt{.00171+.000645}$ $\quad \sigma_{DM_2-M_3} = \pm\sqrt{.00114+.00124}$ $\quad \sigma_{DM_2-M_3} = \pm\sqrt{.00039+.00013}$ $\quad \sigma_{DM_2-M_3} = \pm\sqrt{.00042+.00042}$

$\sigma_D = \pm\sqrt{.002355}$ $\quad \sigma_D = \pm\sqrt{.00238}$ $\quad \sigma_D = \pm\sqrt{.00052}$ $\quad \sigma_D = \pm\sqrt{.00084}$

$= \pm .048528$ $\quad = \pm .04878$ $\quad = \pm .0228$ $\quad = \pm .02898$

0.83 − 0.82 = 0.01 not significant

0.90 − 0.95 = −0.05 not significant

0.98 − 0.96 = 0.02 not significant

1.02 − 0.99 = 0.03 not significant

Table VI (continued)

1947-48	N.A.	B.D.	M.F.	R.R.
	$\sigma_{DM_1-M_3} = \pm\sqrt{.00137+.000645}$	$\sigma_{DM_1-M_3} = \pm\sqrt{.001025+.00124}$	$\sigma_{DM_1-M_3} = \pm\sqrt{.003215+.00013}$	$\sigma_{DM_1-M_3} = \pm\sqrt{.001515+.00042}$
	$\sigma_D = \pm\sqrt{.002015}$	$\sigma_D = \pm\sqrt{.002265}$	$\sigma_D = \pm\sqrt{.003345}$	$\sigma_D = \pm\sqrt{.001935}$
	$= \pm$ .044888	$= \pm$ .04759	$= \pm$ .057835	$= \pm$ .043988
	1.02	1.19	1.26	1.27
	- 0.82	- 0.95	- 0.96	- 0.99
	0.20 significant	0.24 significant	0.30 significant	0.28 significant

Table VI (continued)

1946-47	J.C.			V.D.			J.J.			G.S.		
Sat'n Date	x	d	d^2	x	d	d^2	x	d	d^2	x	d	d^2
2-25	0.93	-0.14	.0196	0.99	-0.02	.0004	0.68	-0.22	.0484	1.10	+0.03	.0009
2-26	0.99	-0.08	.0064	0.92	-0.09	.0081	0.85	-0.05	.0025	1.06	-0.01	.0001
2-27	1.24	+0.17	.0289	0.89	-0.12	.0144	0.96	+0.06	.0036	1.00	-0.07	.0049
2-28	1.16	+0.09	.0081	1.03	+0.02	.0004	1.12	+0.22	.0484	1.07	0.00	.0000
3- 1	1.05	-0.02	.0004	1.22	+0.21	.0441	0.91	+0.01	.0001	1.13	+0.06	.0036
	1.07	±0.10	.0634	1.01	±0.09	.0674	0.90	±0.11	.1030	1.07	±0.03	.0095

$\sigma_{M_1} = \pm\sqrt{\frac{.0634}{20}}$ $\sigma_{M_1} = \pm\sqrt{\frac{.0674}{20}}$ $\sigma_{M_1} = \pm\sqrt{\frac{.1030}{20}}$ $\sigma_{M_1} = \pm\sqrt{\frac{.0095}{20}}$

$= \pm\sqrt{.00317}$ $= \pm\sqrt{.00337}$ $= \pm\sqrt{.00515}$ $= \pm\sqrt{.000475}$

$= \pm .0563$ $= \pm .05805$ $= \pm .07176$ $= \pm .02179$

N.R.C. Date												
3- 4	0.98	+0.07	.0049	0.82	0.00	.0000	1.02	+0.12	.0144	0.95	+0.09	.0081
3- 5	0.88	-0.03	.0009	0.85	+0.03	.0009	0.86	-0.04	.0016	0.86	0.00	.0000
3- 6	0.82	-0.09	.0081	0.72	-0.10	.0100	0.86	-0.04	.0016	0.86	0.00	.0000
3- 7	0.89	-0.02	.0004	0.84	+0.02	.0004	0.90	0.00	.0000	0.86	0.00	.0000
3- 8	0.99	+0.08	.0064	0.85	+0.03	.0009	0.84	-0.06	.0036	0.77	-0.09	.0081
	0.91	±0.06	.0207	0.82	±0.04	.0122	0.90	±0.05	.0212	0.86	±0.04	.0162

$\sigma_{M_2} = \pm\sqrt{\frac{.0207}{20}}$ $\sigma_{M_2} = \pm\sqrt{\frac{.0122}{20}}$ $\sigma_{M_2} = \pm\sqrt{\frac{.0212}{20}}$ $\sigma_{M_2} = \pm\sqrt{\frac{.0162}{20}}$

$= \pm\sqrt{.001035}$ $= \pm\sqrt{.00061}$ $= \pm\sqrt{.00106}$ $= \pm\sqrt{.00081}$

$= \pm .03217$ $= \pm .02146$ $= \pm .03255$ $= \pm .0284$

Table VI (continued)

1946-47	J.C.			V.D.			J.J.			G.S.		
N.R.C.-10 mg.	x	d	d^2	x	d	d^2	x	d	d^2	x	d	d^2
Date												
3-11	0.86	+0.07	.0049	0.69	-0.06	.0036	0.96	+0.16	.0256	0.94	+0.10	.0100
3-12	0.82	+0.03	.0009	0.88	+0.13	.0169	0.75	-0.05	.0025	0.79	-0.05	.0025
3-13	0.81	+0.02	.0004	0.68	-0.07	.0049	0.69	-0.11	.0121	0.82	-0.02	.0004
3-14	0.84	+0.05	.0025	0.72	-0.03	.0009	0.79	-0.01	.0001	0.81	-0.03	.0009
3-15	0.63	-0.16	.0256	0.79	+0.04	.0016	0.81	+0.01	.0001	0.84	0.00	.0000
	0.79	±0.07	.0343	0.75	±0.07	.0279	0.80	±0.07	.0404	0.84	±0.04	.0138

$\sigma_{M_3} = \pm\sqrt{\frac{.0343}{20}}$ $\quad \sigma_{M_3} = \pm\sqrt{\frac{.0279}{20}}$ $\quad \sigma_{M_3} = \pm\sqrt{\frac{.0404}{20}}$ $\quad \sigma_{M_3} = \pm\sqrt{\frac{.0138}{20}}$

$= \pm\sqrt{.001715}$ $\quad = \pm\sqrt{.001395}$ $\quad = \pm\sqrt{.00202}$ $\quad = \pm\sqrt{.00069}$

$= \pm .041141$ $\quad = \pm .037349$ $\quad = \pm .044944$ $\quad = \pm .0262$

$\sigma_{DM_1-M_2} = \pm\sqrt{.00317+.001035}$ $\quad \sigma_{DM_1-M_2} = \pm\sqrt{.00337+.00061}$ $\quad \sigma_{DM_1-M_2} = \pm\sqrt{.00515+.00106}$ $\quad \sigma_{DM_1-M_2} = \pm\sqrt{.000475+.00081}$

$\sigma_D = \pm\sqrt{.004205}$ $\quad \sigma_D = \pm\sqrt{.00398}$ $\quad \sigma_D = \pm\sqrt{.00621}$ $\quad \sigma_D = \pm\sqrt{.001285}$

$= \pm .064845$ $\quad = \pm .06308$ $\quad = \pm .0788$ $\quad = \pm .03584$

1.07 − 0.91 = 0.16 significant

1.01 − 0.82 = 0.19 significant

0.90 − 0.90 = 0.00 not significant

1.07 − 0.86 = 0.21 significant

$\sigma_{DM_2-M_3} = \pm\sqrt{.001035+.001715}$ $\quad \sigma_{DM_2-M_3} = \pm\sqrt{.00061+.001395}$ $\quad \sigma_{DM_2-M_3} = \pm\sqrt{.00106+.00202}$ $\quad \sigma_{DM_2-M_3} = \pm\sqrt{.00081+.00069}$

$\sigma_D = \pm\sqrt{.002750}$ $\quad \sigma_D = \pm\sqrt{.002005}$ $\quad \sigma_D = \pm\sqrt{.00308}$ $\quad \sigma_D = \pm\sqrt{.00150}$

$= \pm .05244$ $\quad = \pm .04477$ $\quad = \pm .05549$ $\quad = \pm .038729$

0.91 − 0.79 = 0.12 significant

0.82 − 0.75 = 0.07 not significant

0.90 − 0.80 = 0.10 not significant

0.86 − 0.84 = 0.02 not significant

Table VI (continued)

1946-47	J.C.	V.D.	J.J.	G.S.
	$\sigma_{DM_1-M_3} = \pm\sqrt{.00317+.001715}$	$\sigma_{DM_1-M_3} = \pm\sqrt{.00337+.001395}$	$\sigma_{DM_1-M_3} = \pm\sqrt{.00515+.00202}$	$\sigma_{DM_1-M_3} = \pm\sqrt{.000475+.00069}$
	$\sigma_D = \pm\sqrt{.004885}$	$\sigma_D = \pm\sqrt{.004765}$	$\sigma_D = \pm\sqrt{.00717}$	$\sigma_D = \pm\sqrt{.001165}$
	$= \pm$ .06989	$= \pm$ .06902	$= \pm$ .08467	$= \pm$ .03413
	1.07	1.01	0.90	1.07
	- 0.79	- 0.75	- 0.80 not	- 0.84
	0.28 significant	0.26 significant	0.10 significant	0.23 significant

Table VI (continued)

1947-48	T.C.			D.E.			W.P.			D.R.		
	Deviation calculated on last 8 days of each period											
Sat'n	x	d	d^2	x	d	d^2	x	d	d^2	x	d	d^2
Date												
2- 3	0.39	-0.41	.1681	0.38	-0.33	.1089	0.99	-0.12	.0144	0.87	-0.17	.0289
2- 4	0.46	-0.34	.1156	0.43	-0.28	.0784	1.18	+0.07	.0049	1.00	-0.04	.0016
2- 5	0.54	-0.26	.0676	0.48	-0.23	.0529	1.12	+0.01	.0001	1.03	-0.01	.0001
2- 6	0.63	-0.17	.0289	0.63	-0.08	.0064	1.06	-0.05	.0025	1.07	+0.03	.0009
2- 7	0.87	+0.07	.0049	0.92	+0.21	.0441	0.99	-0.12	.0144	1.15	+0.11	.0121
2- 8	1.14	+0.34	.1156	0.89	+0.18	.0324	1.32	+0.21	.0441	0.94	-0.10	.0100
2- 9	1.02	+0.22	.0484	0.90	+0.19	.0361	1.08	-0.03	.0009	1.09	+0.05	.0025
2-10	1.31	+0.51	.2601	1.06	+0.35	.1225	1.16	+0.05	.0025	1.18	+0.14	.0196
	0.80	±0.29	.8092	0.71	±0.23	.4817	1.11	±0.08	.0838	1.04	±0.08	.0757
	$\sigma_{M_1} = \pm\sqrt{\frac{.8092}{56}}$			$\sigma_{M_1} = \pm\sqrt{\frac{.4817}{56}}$			$\sigma_{M_1} = \pm\sqrt{\frac{.0838}{56}}$			$\sigma_{M_1} = \pm\sqrt{\frac{.0757}{56}}$		
	$= \pm\sqrt{.014445}$			$= \pm\sqrt{.008602}$			$= \pm\sqrt{.001496}$			$= \pm\sqrt{.001352}$		
	$= \pm$ .1202			$= \pm$ .09274			$= \pm$ .03867			$= \pm$ .03676		
N.R.C.												
Date												
2-13	0.96	+0.06	.0036	0.66	-0.03	.0009	0.74	-0.05	.0025	0.69	-0.04	.0016
2-14	0.87	-0.03	.0009	0.69	0.00	.0000	0.76	-0.03	.0009	0.84	+0.11	.0121
2-15	0.90	0.00	.0000	0.77	+0.08	.0064	0.72	-0.07	.0049	0.83	+0.10	.0100
2-16	0.84	-0.06	.0036	0.72	+0.03	.0009	0.85	+0.06	.0036	0.72	-0.01	.0001
2-17	0.91	+0.01	.0001	0.66	-0.03	.0009	0.78	-0.01	.0001	0.64	-0.09	.0081
2-18	0.91	+0.01	.0001	0.74	+0.05	.0025	0.85	+0.06	.0036	0.70	-0.03	.0009
2-19	0.91	+0.01	.0001	0.63	-0.06	.0036	0.75	-0.04	.0016	0.70	-0.03	.0009
2-20	0.91	+0.01	.0001	0.62	-0.07	.0049	0.84	+0.05	.0025	0.71	-0.02	.0004
	0.90	±0.02	.0085	0.69	±0.04	.0201	0.79	±0.05	.0197	0.73	±0.05	.0341
	$\sigma_{M_2} = \pm\sqrt{\frac{.0085}{56}}$			$\sigma_{M_2} = \pm\sqrt{\frac{.0201}{56}}$			$\sigma_{M_2} = \pm\sqrt{\frac{.0197}{56}}$			$\sigma_{M_2} = \pm\sqrt{\frac{.0341}{56}}$		
	$= \pm\sqrt{.000152}$			$= \pm\sqrt{.000359}$			$= \pm\sqrt{.000352}$			$= \pm\sqrt{.000609}$		
	$= \pm$ .01232			$= \pm$ .01894			$= \pm$ .01876			$= \pm$ .02467		

Table VI (continued)

1947-48	Deviation calculated on last 8 days of each period											
	T.C.			D.E.			W.P.			D.R.		
N.R.C.-10 mg.	x	d	d^2	x	d	d^2	x	d	d^2	x	d	d^2
Date												
2-23	0.93	+0.11	.0121	0.61	-0.06	.0036	0.72	0.00	.0000	0.68	-0.05	.0025
2-24	0.73	-0.09	.0081	0.67	0.00	.0000	0.62	-0.10	.0100	0.59	-0.14	.0196
2-25	0.69	-0.13	.0169	0.71	+0.04	.0016	0.73	+0.01	.0001	0.89	+0.16	.0256
2-26	0.85	+0.03	.0009	0.67	0.00	.0000	0.69	-0.03	.0009	0.75	+0.02	.0004
2-27	0.76	-0.06	.0036	0.66	-0.01	.0001	0.71	-0.01	.0001	0.83	+0.10	.0100
2-28	0.93	+0.11	.0121	0.71	+0.04	.0016	0.69	-0.03	.0009	0.83	+0.10	.0100
2-29	0.85	+0.03	.0009	0.65	-0.02	.0004	0.88	+0.16	.0256	0.59	-0.14	.0196
3- 1	0.79	-0.03	.0009	0.70	+0.03	.0009	0.71	-0.01	.0001	0.68	-0.05	.0025
	0.82	±0.07	.0555	0.67	±0.03	.0082	0.72	±0.04	.0377	0.73	±0.10	.0902

$\sigma_{M_3} = \pm\sqrt{\frac{.0555}{56}}$ $\quad \sigma_{M_3} = \pm\sqrt{\frac{.0082}{56}}$ $\quad \sigma_{M_3} = \pm\sqrt{\frac{.0377}{56}}$ $\quad \sigma_{M_3} = \pm\sqrt{\frac{.0902}{56}}$

$= \pm\sqrt{.000991}$ $\quad = \pm\sqrt{.000146}$ $\quad = \pm\sqrt{.000673}$ $\quad = \pm\sqrt{.001611}$

$= \pm .03148$ $\quad = \pm .01208$ $\quad = \pm .02594$ $\quad = \pm .04013$

$\sigma_{DM_1-M_2} = \pm\sqrt{.011445+.000152}$ $\quad \sigma_{DM_1-M_2} = \pm\sqrt{.008602+.000359}$ $\quad \sigma_{DM_1-M_2} = \pm\sqrt{.001496+.000352}$ $\quad \sigma_{DM_1-M_2} = \pm\sqrt{.001352+.000609}$

$\sigma_D = \pm\sqrt{.011602}$ $\quad \sigma_D = \pm\sqrt{.008961}$ $\quad \sigma_D = \pm\sqrt{.001848}$ $\quad \sigma_D = \pm\sqrt{.001961}$

$= \pm .12083$ $\quad = \pm .09466$ $\quad = \pm .042988$ $\quad = \pm .04428$

0.80 − 0.90 = −0.10 not significant

0.71 − 0.69 = 0.02 not significant

1.11 − 0.79 = 0.32 significant

1.04 − 0.73 = 0.31 significant

Table VI (continued)

1947-48	T.C.	D.E.	W.P.	D.R.
	$\sigma_{DM_2-M_3}=\pm\sqrt{.0001524+.000991}$	$\sigma_{DM_2-M_3}=\pm\sqrt{.000359+.000146}$	$\sigma_{DM_2-M_3}=\pm\sqrt{.000352+.000673}$	$\sigma_{DM_2-M_3}=\pm\sqrt{.000609+.001611}$
	$\sigma_D=\pm\sqrt{.001143}$	$\sigma_D=\pm\sqrt{.000505}$	$\sigma_D=\pm\sqrt{.001025}$	$\sigma_D=\pm\sqrt{.002220}$
	$=\pm$ .033808	$=\pm$ .02247	$=\pm$ .03201	$=\pm$ .04711
	0.90	0.69	0.79	0.73
	- 0.82	- 0.67 not	- 0.72	- 0.73 not
	0.08 significant	0.02 significant	0.07 significant	0.00 significant
	$\sigma_{DM_1-M_3}=\pm\sqrt{.011445+.000991}$	$\sigma_{DM_1-M_3}=\pm\sqrt{.008602+.000146}$	$\sigma_{DM_1-M_3}=\pm\sqrt{.001496+.000673}$	$\sigma_{DM_1-M_3}=\pm\sqrt{.001352+.001611}$
	$\sigma_D=\pm\sqrt{.015441}$	$\sigma_D=\pm\sqrt{.008748}$	$\sigma_D=\pm\sqrt{.002169}$	$\sigma_D=\pm\sqrt{.002963}$
	$=\pm$ .12426	$=\pm$ .09353	$=\pm$ .04657	$=\pm$ .054443
	0.80	0.71	1.11	1.04
	- 0.82 not	- 0.67 not	- 0.72	- 0.73
	-0.02 significant	0.04 significant	0.39 significant	0.31 significant

Table VI (continued)

1947-48	Deviation calculated on last 5 days of each period											
	T.C.			D.E.			W.P.			D.R.		
Sat'n	x	d	d^2	x	d	d^2	x	d	d^2	x	d	d^2
Date												
2- 6	0.63	-0.36	.1296	0.63	-0.25	.0625	1.06	-0.06	.0036	1.07	-0.02	.0004
2- 7	0.87	-0.12	.0144	0.92	+0.04	.0016	0.99	-0.13	.0169	1.15	+0.06	.0036
2- 8	1.14	+0.15	.0225	0.89	+0.01	.0001	1.32	+0.20	.0400	0.94	-0.15	.0225
2- 9	1.02	+0.03	.0009	0.90	+0.02	.0004	1.08	-0.04	.0016	1.09	0.00	.0000
2-10	1.31	+0.32	.1024	1.06	+0.18	.0324	1.16	+0.04	.0016	1.18	+0.09	.0081
	0.99	±0.20	.2698	0.88	±0.10	.0970	1.12	±0.09	.0637	1.09	±0.06	.0346
	$\sigma_{M_1} = \pm\sqrt{\frac{.2698}{20}}$			$\sigma_{M_1} = \pm\sqrt{\frac{.0970}{20}}$			$\sigma_{M_1} = \pm\sqrt{\frac{.0637}{20}}$			$\sigma_{M_1} = \pm\sqrt{\frac{.0346}{20}}$		
	$= \pm\sqrt{.01349}$			$= \pm\sqrt{.00485}$			$= \pm\sqrt{.003185}$			$= \pm\sqrt{.00173}$		
	$= \pm$ .11614			$= \pm$ .06964			$= \pm$ .056435			$= \pm$ .04159		
N.R.C.												
Date												
2-16	0.84	-0.06	.0036	0.72	+0.05	.0025	0.85	+0.04	.0016	0.72	+0.03	.0009
2-17	0.91	+0.01	.0001	0.66	-0.01	.0001	0.78	-0.03	.0009	0.64	-0.05	.0025
2-18	0.91	+0.01	.0001	0.74	+0.07	.0049	0.85	+0.04	.0016	0.70	+0.01	.0001
2-19	0.91	+0.01	.0001	0.63	-0.04	.0016	0.75	-0.06	.0036	0.70	+0.01	.0001
2-20	0.91	+0.01	.0001	0.62	-0.05	.0025	0.84	+0.03	.0009	0.71	+0.02	.0004
	0.90	±0.02	.0040	0.67	±0.04	.0116	0.81	±0.04	.0086	0.69	±0.02	.0040
	$\sigma_{M_2} = \pm\sqrt{\frac{.0040}{20}}$			$\sigma_{M_2} = \pm\sqrt{\frac{.0116}{20}}$			$\sigma_{M_2} = \pm\sqrt{\frac{.0086}{20}}$			$\sigma_{M_2} = \pm\sqrt{\frac{.0040}{20}}$		
	$= \pm\sqrt{.0002}$			$= \pm\sqrt{.00058}$			$= \pm\sqrt{.00043}$			$= \pm\sqrt{.0002}$		
	$= \pm$ .01414			$= \pm$ .02408			$= \pm$ .020736			$= \pm$ .01414		

Table VI (continued)

1947-48	T.C.			D.E.			W.P.			D.R.		
	Deviation calculated on last 5 days of each period											
N.R.C.-10 mg.	x	d	d^2	x	d	d^2	x	d	d^2	x	d	d^2
Date												
2-26	0.85	+0.01	.0001	0.67	-0.01	.0001	0.69	-0.05	.0025	0.75	+0.01	.0001
2-27	0.76	-0.08	.0064	0.66	-0.02	.0004	0.71	-0.03	.0009	0.83	+0.09	.0081
2-28	0.93	+0.09	.0081	0.71	+0.03	.0009	0.69	-0.05	.0025	0.83	+0.09	.0081
2-29	0.85	+0.01	.0001	0.65	-0.03	.0009	0.88	+0.14	.0196	0.59	-0.15	.0225
3- 1	0.79	-0.05	.0025	0.70	+0.02	.0004	0.71	-0.03	.0009	0.68	-0.06	.0036
	0.84	±0.05	.0172	0.68	±0.02	.0027	0.74	±0.06	.0264	0.74	±0.08	.0424

$\sigma_{M_3} = \pm\sqrt{\frac{.0172}{20}}$ $\quad \sigma_{M_3} = \pm\sqrt{\frac{.0027}{20}}$ $\quad \sigma_{M_3} = \pm\sqrt{\frac{.0264}{20}}$ $\quad \sigma_{M_3} = \pm\sqrt{\frac{.0424}{20}}$

$= \pm\sqrt{.00086}$ $\quad = \pm\sqrt{.000135}$ $\quad = \pm\sqrt{.00132}$ $\quad = \pm\sqrt{.00212}$

$= \pm .02932$ $\quad = \pm .01161$ $\quad = \pm .03633$ $\quad = \pm .04604$

$\sigma_{DM_1-M_2} = \pm\sqrt{.01349+.0002}$ $\quad \sigma_{DM_1-M_2} = \pm\sqrt{.00485+.00058}$ $\quad \sigma_{DM_1-M_2} = \pm\sqrt{.003185+.00043}$ $\quad \sigma_{DM_1-M_2} = \pm\sqrt{.00173+.0002}$

$\sigma_D = \pm\sqrt{.01369}$ $\quad \sigma_D = \pm\sqrt{.00543}$ $\quad \sigma_D = \pm\sqrt{.003615}$ $\quad \sigma_D = \pm\sqrt{.00193}$

$= \pm .0117$ $\quad = \pm .07368$ $\quad = \pm .060124$ $\quad = \pm .04393$

0.99 − 0.90 = 0.09 significant

0.88 − 0.67 = 0.21 significant

1.12 − 0.81 = 0.31 significant

1.09 − 0.69 = 0.40 significant

$\sigma_{DM_2-M_3} = \pm\sqrt{.0002+.00086}$ $\quad \sigma_{DM_2-M_3} = \pm\sqrt{.00058+.000135}$ $\quad \sigma_{DM_2-M_3} = \pm\sqrt{.00043+.00132}$ $\quad \sigma_{DM_2-M_3} = \pm\sqrt{.0002+.00212}$

$\sigma_D = \pm\sqrt{.00106}$ $\quad \sigma_D = \pm\sqrt{.000715}$ $\quad \sigma_D = \pm\sqrt{.00175}$ $\quad \sigma_D = \pm\sqrt{.00232}$

$= \pm .03255$ $\quad = \pm .026739$ $\quad = \pm .041833$ $\quad = \pm .04816$

0.90 − 0.84 = 0.06 not significant

0.67 − 0.68 = −0.01 not significant

0.81 − 0.74 = 0.07 not significant

0.69 − 0.74 = −0.05 not significant

Table VI (continued)

1947-48	T.C.	D.E.	W.P.	D.R.
	$\sigma_{DM_1-M_3} = \pm\sqrt{.01349+.00086}$	$\sigma_{DM_1-M_3} = \pm\sqrt{.00485+.000135}$	$\sigma_{DM_1-M_3} = \pm\sqrt{.003185+.00132}$	$\sigma_{DM_1-M_3} = \pm\sqrt{.00173+.00212}$
	$\sigma_D = \pm\sqrt{.01435}$	$\sigma_D = \pm\sqrt{.004985}$	$\sigma_D = \pm\sqrt{.004505}$	$\sigma_D = \pm\sqrt{.00385}$
	$= \pm$ .011979	$= \pm$ .070604	$= \pm$ .067119	$= \pm$ .06204
	0.99	0.88	1.12	1.09
	- 0.84	- 0.68	- 0.74	- 0.74
	0.15 significant	0.20 significant	0.38 significant	0.35 significant

Table VII

Significance of the Means by Analysis of Variance
for the Concentration of Ascorbic Acid in Plasma

A. Adolescent Girls

Subject	M.G.	W.H.	B.R.	P.S.	N.A.	B.D.	M.F.	R.R.
	Plasma A.A. Mg %	Plasma A.A. Mg %	Plasma A.A. Mg %	Plasma A.A. Mg %	Plasma A.A. Mg %	Plasma A.A. Mg %	Plasma A.A. Mg %	Plasma A.A. Mg %
Saturation Period	1.13	1.06	1.13	1.28	0.90	1.23	1.10	1.27
	1.19	1.20	1.24	1.17	1.07	1.29	1.35	1.17
	1.14	1.01	1.07	1.13	0.98	1.17	1.19	1.40
	1.04	1.00	1.17	1.29	1.07	1.12	1.25	1.22
	1.13	1.30	1.14	1.20	1.10	1.13	1.42	1.30
N.R.C. Period	1.15	1.00	0.93	1.08	0.89	0.94	1.01	1.05
	0.96	0.99	1.00	1.16	0.94	0.78	0.96	1.09
	1.09	1.06	0.99	1.15	0.85	0.90	0.96	1.01
	0.88	0.80	0.93	1.10	0.73	0.98	0.93	0.98
	0.89	0.97	0.99	0.87	0.74	0.88	1.04	0.99
N.R.C. - 10 mg	0.75	0.83	0.86	1.12	0.84	1.00	0.99	0.96
	0.78	0.76	0.87	1.09	0.72	0.82	0.96	0.94
	0.90	0.85	0.99	1.15	0.82	0.96	0.99	0.96
	0.92	0.72	0.99	0.96	0.85	0.97	0.94	1.03
	0.93	0.86	0.89	0.86	0.86	1.02	0.94	1.04

Table of Totals

Periods									Totals	Means
Saturation	5.63	5.57	5.75	6.07	5.12	5.94	6.31	6.36	46.75	1.17
N.R.C.	4.97	4.82	4.84	5.36	4.15	4.48	4.90	5.12	38.64	0.97
N.R.C. - 10 mg	4.28	4.02	4.60	5.18	4.09	4.77	4.82	4.93	36.69	0.92
Totals	14.88	14.41	15.19	16.61	13.36	15.19	16.03	16.41	122.08	
Means	0.99	0.96	1.01	1.11	0.89	1.01	1.07	1.09		

	ΣX^2	divisor	$\frac{\Sigma X^2}{\text{divisor}}$	s.s.
Person	1871.1654	15	124.7444	0.5483
Period	5024.7682	40	125.6192	1.4231
Group	631.4882	5	126.2976	2.1015
Error	---	--	---	0.6560
Total	126.9536	1	126.9536	2.7575
Correction	14903.5264	120	124.1961	
Interaction s.s.		.1301		

1.17
- 0.97
0.20 significant

0.97
- 0.92
0.05 significant

Variation	d.f.	s.s	variance	F	
Person	7	0.5483	0.0783286	11.46	significant
Period	2	1.4231	0.7116	104.14	significant
Interaction	14	0.1301	0.0092929	1.36	not significant
Error	96	0.6560	0.006833	---	
Total	119	2.7575	---	---	

Table VII

Significance of the Means by Analysis of Variance
for the Concentration of Ascorbic Acid in Plasma

B. Adolescent Boys

Subject	J.C.	V.D.	G.S.	T.C.	D.E.	W.P.	D.R.
	Plasma A.A. Mg %	Plasma A.A. Mg %	Plasma A.A. Mg %	Plasma A.A. Mg %	Plasma A.A. Mg %	Plasma A.A. Mg %	Plasma A.A. Mg %
Saturation Period	0.93	0.99	1.10	0.63	0.63	1.06	1.07
	0.99	0.92	1.06	0.87	0.92	0.99	1.15
	1.24	0.89	1.00	1.14	0.89	1.32	0.94
	1.16	1.03	1.07	1.02	0.90	1.08	1.09
	1.05	1.22	1.13	1.31	1.06	1.16	1.18
N.R.C. Period	0.98	0.82	0.95	0.84	0.72	0.85	0.72
	0.88	0.85	0.86	0.91	0.66	0.78	0.64
	0.82	0.72	0.86	0.91	0.74	0.85	0.70
	0.89	0.84	0.86	0.91	0.63	0.75	0.70
	0.99	0.85	0.77	0.91	0.62	0.84	0.71
N.R.C. - 10 mg Period	0.86	0.69	0.94	0.85	0.67	0.69	0.75
	0.82	0.88	0.79	0.76	0.66	0.71	0.83
	0.81	0.68	0.82	0.93	0.71	0.69	0.83
	0.84	0.72	0.81	0.85	0.65	0.88	0.59
	0.63	0.79	0.84	0.79	0.70	0.71	0.68

Table of Totals

Periods								Totals	Means
Saturation	5.37	5.05	5.36	4.97	4.40	5.61	5.43	36.19	1.03
N.R.C.	4.56	4.08	4.30	4.48	3.37	4.07	3.47	28.33	0.81
N.R.C. - 10 mg	3.96	3.76	4.20	4.18	3.39	3.68	3.68	26.85	0.77
Totals	13.89	12.89	13.86	13.63	11.16	13.36	12.58	91.37	
Means	0.93	0.86	0.92	0.91	0.74	0.89	0.84		

	ΣX^2	divisor	$\frac{\Sigma X^2}{\text{divisor}}$	s.s.
Person	1198.2523	15	79.8834866	0.3741828
Period	2833.2275	35	80.9493571	1.4400533
Group	407.5585	5	81.5117	2.0023962
Error	---	--	---	0.8464
Total	82.3581	1	82.3581	2.8487962
Correction	8348.4769	105	79.5093038	

Interaction s.s. 0.1882

1.03		
- 0.81		
0.22	significant	
0.81		
- 0.77	not	
0.04	significant	

Variation	d.f.	s.s.	variance	F	
Person	6	0.3741828	0.0623638	6.189	significant
Period	2	1.4400533	0.7200267	71.4595	significant
Interaction	12	0.1881601	0.0156800	1.5561	not significant
Error	84	0.8464	0.010076	---	
Total	104	2.8487962	---	---	

Table VIII

The "T" test for Least Significant Difference Between Means for the Concentration of Ascorbic Acid in the Plasma

A. Adolescent Girls

Least significant (5%) difference between any two means of periods:

$$t_{.05}\sqrt{\frac{2(.006833)}{40}} \quad \text{with 96 d.f.}$$

$$1.985\sqrt{\frac{2(.006833)}{40}}$$

$$1.985\sqrt{\frac{.013666}{40}}$$

$$1.985\sqrt{.000342}$$

$$(1.985)(.01849)$$

$$0.03670$$

Least significant (5%) difference between any two means of persons:

$$t_{.05}\sqrt{\frac{2(.006833)}{15}} \quad \text{with 96 d.f.}$$

$$1.985\sqrt{\frac{2(.006833)}{15}}$$

$$1.985\sqrt{\frac{.013666}{15}}$$

$$1.985\sqrt{.000911}$$

$$(1.985)(.030183)$$

$$0.05991$$

Table VIII - (continued)

The "T" test for Least Significant Difference Between Means for the Concentration of Ascorbic Acid in the Plasma

B. Adolescent Boys

Least significant (5%) difference between any two means of periods:

$$t.05\sqrt{\frac{2(.010076)}{35}} \quad \text{with 84 d.f.}$$

$$1.989\sqrt{\frac{2(.010076)}{35}}$$

$$1.989\sqrt{\frac{.020152}{35}}$$

$$1.989\sqrt{.000576}$$

$$(1.989)(.024)$$

$$0.047736$$

Least significant (5%) difference between any two means of persons:

$$t.05\sqrt{\frac{2(.010076)}{15}} \quad \text{with 84 d.f.}$$

$$1.989\sqrt{\frac{2(.010076)}{15}}$$

$$1.989\sqrt{\frac{.020152}{15}}$$

$$1.989\sqrt{.001343}$$

$$(1.989)(.03665)$$

$$0.072897$$

Table IX

Comparison of Mean Plasma Ascorbic Acid Values of Boys and Girls

	No. of observations	Mean $\bar{X}$	Variance S^2	d.f.
Girls	120	1.0173	0.006833	96
Boys	105	0.8702	0.010076	84

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{S_1^2}{N_1} + \frac{S_2^2}{N_2}}} = \frac{1.0173 - 0.8702}{\sqrt{\frac{0.006833}{120} + \frac{0.010076}{105}}}$$

$$= \frac{0.1471}{\sqrt{0.00005694 + 0.00009596}}$$

$$= \frac{0.1471}{\sqrt{0.00015290}}$$

$$= \frac{0.1471}{0.01237}$$

$$= 11.89 \quad \text{with } 84 \text{ d.f.}$$