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Body measurements and blood constituents in relation to nutrient intake of Iowa children

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BODY MEASUREMENTS AND BLOOD CONSTITUENTS IN RELATION TO NUTRIENT INTAKE OF IOWA CHILDREN

by

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TABLE OF CONTENTS

INTRODUCTION

Since the first dietary studies were conducted in the United States by the Office of Experiment Stations in the early years of the twentieth century, efforts have been made to relate the dietary intake to certain physical conditions. At that time workers noted that families who had restricted diets did not look as healthy and well-kept as those who had a varied diet (Hills, Wait and White, 1909).

As yet, very few highly significant statistical relationships have been obtained between nutrient intake and physical or chemical characteristics of the individuals. Several investigators have attempted to explain the lack of correlation. Putman *et al*. (1949) and Sinclair (1948) claimed it to be due to experimental errors, to incorrect interpretation of the data, or a combination of these factors.

Kruse (1942) called attention to the time element that is involved in the development of tissue evidence of the deficiency diseases, and in the differences of the blood plasma concentrations from week to week.

In Nutrition Reviews (1945) this comment appeared near the close of the discussion of the North Carolina survey:

> It would appear that there is a fundamental fallacy inherent in the short term nutrition survey in which dietary history, or careful records of food intake, physical measurements, biochemical and nicrobiological determinations are carried out in so short a span. . . . The clinical signs which are diagnostic of deficiency diseases result from protracted deficiencies, the biochemical status at an instant of time is a composite of underlying stores or deficits and the balance between recent losses and recent accruals from intake; and the dietary story is accurate only for the particular time when records are kept. (p. 108)

The relationship between nutrient intakes and indices of nutritional status may be further obscured by the prevailing individual variation within the so-called normal range. Babcock *et al.* (1953) stated that

> . . . high correlation between nutrients ingested and concentration of blood constituents can not be obtained within the range of normal individual variation. Also at high levels of nutrient intake the tendency for the body to store, destroy or excrete excess nutrients and the general absence of gross lesions may prevent high correlation of blood and physical findings with dietary intake. Higher correlations are to be expected, therefore, from subjects whose nutritional status ranges from very poor to fair. (p. 8)

All these factors probably do play an important role in obscuring the relationships between chemical and physical findings, and the dietary intake.

Variations within age-sex groups throughout the school years have not been studied intensively. One of the aims in this study was to observe the differences in nutrient intakes and blood constituents of the children in relation to differences in various physical measurements. Each age-sex group in height, weight and developmental level was divided into three smaller groups according to the mean and standard deviation of the age-sex group. One group consisted of children who had physical measurements that were within plus or minus one standard deviation of the mean; another group consisted of children who had physical measurements that were within plus the second and third standard deviation of the mean, and another within minus the second and third standard deviation of the mean. The comparison of the mean values for each nutrient in the diet and of the mean concentrations for each blood constituent for each of the three subgroups by age and sex may be expected to show differences related to physical measurements.

A second aim was to see whether the relationships between the physical, chemical and dietary findings are more apparent in the two extreme groups than in the average or middle group. This method of analysis is exploratory. It may be indicative of relationships which would merit more intensive analysis by regressions and correlations. It may also suggest a basis of sampling children for future nutritional status studies.

SOME NUTRITIONAL STATUS STUDIES OF SCHOOL CHILDREN IN THE UNITED STATES

In the past ten years several studies have been made of large numbers of school children in an effort to evaluate their nutritional status. The investigators of the studies listed in Table 1 had as one of their objectives, the examination of the relationship between the nutrient intake and the physical, chemical and clinical observations.

In four of the studies the investigators observed the same children over a period of time. Abbott et al. (1946) observed 186 children in several rural schools in northern Florida for four years. Children in three orphanages were studied by Mack et al. (1949) for two years. In Groton Township (New York State) Young et al. (1950) observed a group of children in the fall of 1948 and the spring of 1949. In Maine, Clayton (1944) made observations on 220 children from 1936 to 1940. All the other studies were cross-sectional in nature.

Approximately 8500 children were included in the 17 investigations conducted in various sections of the United States. The ages of the children extended from one to twenty years. In these selected studies most of the subjects

Table 1

Some Nutritional Status Studies of Children of School Age in the Un

1943—1953

Place	Investigators	No. of children	Ages yr.	Dietary records	Some Body measurem
Midwest					
Iowa	Smith 1952	100	8-17	7 days	Height - Weig
Iowa	Barbour 1948	63	6-18	7 days	Height - Weig
Wisconsin	Reynolds et al. 1948	458	6-13	8 days	
Michigan	Macy 1948	390	2-18	Weighed diets	Height - Weig
Kansas) Minnesota)	Leichsenring et al. 1943	524	13-18	7 days	Height - Weig
Michigan	Harris et al. 1943	760	7-12	Noon meal	
Northeast					
Northeast Region	Tucker et al. 1952 Clayton et al. 1953 Babcock et al. 1953	1295	4-20	7 day or history	Height - Weig
New York	Young et al.1950 Pilcher et al. 1950 Moore et al. 1951 Williams et al. 1951	323	1-20	1 day	Height - Weig
Pennsylvania	Mack and Urback 1949	585	5-15	Weighed diets	Height - Weig and other anthropometr measurements

Table 1

onal Status Studies of Children of School Age in the United States

1943—1953

	No. of children	Ages yr.	Dietary records	Some of the observations made		
				Body measurements	Blood	Clinical
	100	8-17	7 days	Height - Weight		
	63	6-18	7 days	Height - Weight	Hemoglobin Ascorbic acid	Medical
1948	458	6-13	8 days		Hemoglobin	
	390	2-18	Weighed diets	Height - Weight	Hemoglobin Ascorbic acid Vitamin A Carotenoids Alk. phosphatase	Medical
l. 1943	524	13-18	7 days	Height - Weight		
43	760	7-12	Noon meal		Hemoglobin Ascorbic acid	Medical
52 953 953	1295	4-20	7 day or history	Height - Weight	Hemoglobin Ascorbic acid Vitamin A Carotenoids Alk. phosphatase	Medical
950 1 1951	323	1-20	1 day	Height - Weight	Hemoglobin Ascorbic acid Vitamin A	Medical
1949	585	5-15	Weighed diets	Height - Weight and other anthropometric measurements	Hemoglobin Ascorbic acid Vitamin A Carotenoids Alk. phosphatase	Medical

Table 1 (continued)

Place	Investigators	No. of children	Ages yr.	Dietary records	Some Body measurem
New York	Bessey and Lowry 1947	1200	11-19		
Vermont	Pierce et al. 1945	386	3-15	1 day (history)	Height - Weig
Maine	Clayton 1944	220	5-15	7 day	Height - Weig
Northwest					
Oregon	Storvick et al. 1951	739	14-16	Dietary	Height - Weig
Oregon	Fincke 1946	436	8-18	7 day	Height - Weig
Southern					
Louisiana	Moschette et al. 1952	487	8-11	7 day	Height - Weig
Florida	Abbott et al. 1946	186	6-14	Noon meal	Height - Weig
Tennessee	Youmans et al. 1943	296	6-20	7 day	Height - Weig

	No. of children	Ages yr.	Dietary records	Some of the observations made		
				Body measurements	Blood	Clinical
y 1947	1200	11-19			Hemoglobin Ascorbic acid Vitamin A Carotenoids Alk. phosphatase	
945	386	3-15	1 day (history)	Height - Weight	Hemoglobin Ascorbic acid	Medical
	220	5-15	7 day	Height - Weight	Hemoglobin Ascorbic acid	Medical
, 1951	739	14-16	Dietary	Height - Weight	Hemoglobin Ascorbic acid Vitamin A Carotenoids Alk. phosphatase	Medical
	436	8-18	7 day	Height - Weight	Hemoglobin Ascorbic acid	
l. 1952	487	8-11	7 day	Height - Weight	Hemoglobin Ascorbic acid Vitamin A Carotenoids	Medical
1946	186	6-14	Noon meal	Height - Weight	Hemoglobin	Medical
1943	296	6-20	7 day	Height - Weight	Hemoglobin Ascorbic acid Alk. phosphatase	Medical

were from public schools rather than from orphanages. The studies made by Mack and Urback (1949) and by Macy (1948) involved children in orphanages.

The investigators made a series of measurements of nutritional status of the children, also they obtained from each child a record of his dietary intake for a period of time.

The largest and most complete cross-sectional study of children has just been reported by the research workers of the Northeast Region. It was one of several regional studies of the nutritional status of population groups. The Bureau of Human Nutrition and Home Economics cooperated in certain of these investigations.

Some of the main conclusions of the entire group of studies regarding the nutrient intake and the nutritional status of children are summarized in the following sections.

Nutritive Values of Diet

Apparently many children of school age could improve their dietary practices by consuming more milk, fruits and vegetables. Investigators frequently reported deficient intakes of ascorbic acid-, carotenoid- and calcium-rich foods. (Moschette *et al.*, 1952; Tucker *et al.*, 1952; Storvick *et al.*, 1951.)

In Groton Township, New York State, Pilcher _et al_. (1950) found a higher consumption of fruits and vegetables as the amount of money spent per week or per meal increased in the family expenditures. The rural families used more fruits and vegetables than did the village families.

The dietary habits of a group of one hundred Iowa children studied by Smith (1952) showed that over a period of three years the diets did not improve in the use of milk, fruits and vegetables. The Florida children (Abbott _et al_., 1946) had poor intakes of milk, fruits and vegetables, in addition to the lack of iron due to the iron deficiency in the soil in which most of the food was grown.

Poor intakes of all nutrients were found by Youmans _et al_. (1943) in their observations on the nutritional status of people in a rural community of Tennessee. Over one-third of the subjects had protein intakes that were less than 50 grams. The caloric value of the diets of the children was lower than any of the values reported by other investigators for similar age-sex groups.

These studies from different parts of the country showed that the amount of milk, fruits and vegetables in a child's diet is determined by the family food budget, the season or the availability and the usual dietary habits.

Height and Weight

The majority of the investigators have compared their height-weight data with the standard for boys and girls presented by Baldwin and Wood (1923) and reported the findings in per cent deviation from the standard. According to this standard a fifth to a tenth of the children were ten per cent or more overweight, also an equal percentage was underweight (Babcock et al., 1953; Moschette et al., 1952; and Moore et al., 1951).

Clayton (1944) found that a third of the Maine children in her study were below the mean measurements McCloy observed on Iowa children. Moyer, Beach et al. (1948) compared the institutional Michigan children to Meredith and Boynton Standards. The majority of the children from two of the institutions tended to have weights lower than minus ten per cent of the standard; otherwise the majority of the children had weights equal to or above the standards.

The Florida children had a definite retardation in growth as shown by the placement on the Wetzel Grid. The grid is a device used by Abbott and co-workers to evaluate physical development. In two years under the influence of well-planned school lunches, the children were able to overcome the lag in growth and keep up to schedule.

The data suggested that 10 to 20 per cent of the children of school age were overweight or underweight, as determined by comparison with some standard. The extent of overweight or underweight may vary considerably from area to area. Abbott and co-workers (1946) showed that underweight children may gain weight by eating a well-balanced meal at noon on each school day.

Serum Ascorbic Acid Concentrations

In their report on the serum ascorbic acid status of various groups of institutional children in Michigan, Moyer, Harrison _et al_. (1948) noted a seasonal variation in their spring and fall observations. The range of means for the three institutions was 0.68 to 1.01 mg. per cent in the spring and 0.95 to 1.08 mg. per cent in the fall. These investigators also included a resume of some of the findings on the status of serum and plasma ascorbic acid concentrations of children studied in various sections of the country. In the studies where two observations were made the same seasonal differences were observed. Although Williams _et al_. (1951) obtained practically the same mean serum ascorbic acid concentration for the whole population in the spring and fall, the data showed a shift toward the higher levels in the fall.

In the Northeast Region Clayton et al. (1953) observed the lowest serum ascorbic concentrations among the children in the middle teen ages. The boys had lower values than the girls in this age group. Fincke (1946) in her study of the Oregon children noted no sex differences, but the mean concentrations decreased with age. The percentage of teen-age children in Oregon with serum concentrations less than 0.6 mg. per cent was about the same in the two studies conducted by Fincke (1946) and Storvick et al. (1951).

Bessey and Lowry (1947) found that children from families in the higher socio-economic levels had fewer low concentrations of serum ascorbic acid than the children from the low socio-economic status. No matter what the economic status was, these observers inferred that 50 per cent of the children studied were not getting adequate amounts of dietary ascorbic acid.

The concentration of serum ascorbic acid can be raised by making the school lunch rich in the nutrient. Harris et al. (1943) demonstrated that the children fed a special soup mix had higher concentrations than the controls who had the regular meals.

From these data it appeared that the concentration is influenced by the intake, by the age of the child, also by the sex; that is, the girls tend to have higher levels than the boys at 13 to 15 years. The concentrations tend to be higher in the fall than in the spring, probably due to the higher intake of fresh fruits and vegetables during the summer.

Serum Carotenoid Concentrations

Serum carotenoid concentrations do reflect the carotene intake of an individual. In the study of institutional children, Robinson _et al_. (1948) noted after a six weeks' diet rich in milk, fruits and vegetables a rise in the concentrations of the serum carotenoids of the children who previously had low values.

Among the preadolescent children in Louisiana, Moschette _et al_. (1952) found a small percentage with low serum carotenoid concentrations. Clayton _et al_. (1953) and Storvick _et al_. (1951) reported that one-half to three-fourths of the children studied in the Northeast Region and in the Northwest Region had low concentrations; they were rated fair to poor. Bessey and Lowry (1947) said half of the 1200 New York children had concentrations below 125 micrograms per cent. One-third of the population in Groton Township had concentrations below Williams' arbitrary dividing line, 60 micrograms per cent (Williams et al., 1951).

Clayton et al. (1953) reported significant sex differences at the ages of 13 to 15 years. The boys had lower concentrations than the girls.

From these reports it may be concluded that the serum carotenoid concentrations of children varied with area, with sex, with season and with age, also with intake of carotene-rich foods. No conclusion can be made as to a satisfactory level of this blood constituent.

Serum Alkaline Phosphatase Concentrations

Abnormally high concentrations of serum alkaline phosphatase signify bone deformities (Kay, 1930), abnormally low ones hypothyroidism (Talbot, 1939). There is no agreement concerning a satisfactory normal concentration. Bessey and Lowry (1947) suggested 7 nitrophenol units (millimoles per liter of serum per hour). Williams et al. (1951) concluded that 12 nitrophenol units for children and 5 nitrophenol units for adults were within normal range. Most research workers compare their data with Bessey and Lowry's recommendations.

Several investigators noted sex differences throughout the age range. The girls reached a peak concentration at an earlier age than the boys (Harrison et al., 1948 and Clayton et al., 1953). From the fall to the spring observations Clayton and co-workers reported a shift in the peak values of two nitrophenol units toward higher concentrations. The authors could not fully account for this shift. The boys (13-15 years) were at an age when the levels were expected to rise. The girls (13-15 years) were past the age when a rise due to puberty is expected. This rise, therefore, was due to other factors.

Hemoglobin Concentration in the Blood

The review of the literature relating to the hemoglobin concentration in the blood observed by a number of investigators was reported by Barbour (1948) and Ebersole (1949).

Hemoglobin concentration in the blood is often used as an index of nutritional status, yet its fluctuation from the normal is often only apparent when the subject is under severe deprivation for some time. Reynolds et al. (1948) noted no difference between the hemoglobin concentrations in the blood of children who came from a rich farming area and those who came from a poor farming area. The poorest concentrations were found in the northeastern region of the United States among the girls of child-bearing age (Clayton et al., 1953; Williams et al., 1951). Very few poor values were observed by Bessey and Lowry (1947); and Storvick et al. (1951).

Sex differences were observed by Kaucher et al. (1948); Clayton et al. (1953) and Fincke (1946) after 12 years of age.

The hemoglobin concentrations of under-nourished children improved after they had been fed a nourishing noon meal at school over a period of time (Abbott et al., 1946; Harris, 1943).

Macy (1948) and Mack and Urback (1949) were able to show that the entire nutritional status of children can be improved by feeding children ample amounts of fruits, vegetables and milk. The differences in the nutritional status brought about by the dietary changes of the children were measurable.

METHODS USED TO STUDY THE NUTRITIONAL STATUS OF IOWA CHILDREN

This study is part of a cooperative project with Iowa, Kansas and Ohio Agricultural Experiment Stations and the Bureau of Human Nutrition and Home Economics. Along with this study of food habits and nutritional status of children, an investigation was made of the organization and management of the school lunch program, of certain aspects of nutrition education programs in Iowa schools, and possible relationships between nutritional status indices and school achievements, personality and motor functions. The cooperative aspects broadened the scope of the study but at times influenced methods of procedure.

The subjects in this study were representative of a large population of Iowa school children. The sampling was done according to a plan whereby the schools and the children in the schools were randomly chosen. Among the studies of food habits and nutritional status of school children, the Iowa study is thought to be unique in its efforts to apply scientific sampling methods and thus obtain data representative of a large population of school children.

Sampling of the Population

The following two objectives were chosen as a basis for sampling the population of school children:

1. To obtain some information regarding the food habits and the nutritional status of children who lived in the city, small towns and rural areas of Iowa.

2. To obtain some information regarding the food habits and the nutritional status of children who participated and those who did not participate in a school lunch program.

The statistical personnel from the Iowa State College Statistical Laboratory recommended the following plan for sampling the schools in order to have schools representative of the various areas. The schools in Iowa were classified according to the following categories:

I. According to the population of the city, town or community in which the school is situated

a. Schools in cities of 50,000 or over

b. Schools in cities and towns under 50,000 and all consolidated and independent schools with grades one to twelve

c. Rural elementary schools

II. According to the organization of the schools

a. Junior and senior high schools

b. Elementary schools

c. Consolidated and independent schools with grades one to twelve

III. According to the lunch program

a. Full meal[1]

b. Supplemental food[2]

c. No lunch

d. No information

It was recommended that at least two schools be randomly chosen for each of the ten classifications.

The name, location, enrollment and number of grades in the school were obtained from the Iowa Educational Directory and from the records of the county superintendents. The name and the location of each school receiving federal reimbursement for full meals and for a milk program were

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[1]By full meal was meant a meal that supposedly met the federal government's specification for a type A lunch, or a complete hot meal was available to the child.

[2]By supplemental food was meant either milk or a hot dish was supplied by the school to supplement the lunch brought from home.

provided by the Director of the Iowa School Lunch Program. A questionnaire was mailed to the administrators of the other schools to determine whether they were operating a school lunch program, and if so what kind of a meal was served.

The information regarding each Iowa school was tallied according to the various categories. The results are shown in Tables 92, 93 and 94 (Appendix).

The sample of schools was drawn randomly from the list of schools under each category. Snedecor's table of "randomly assorted digits" was used for drawing the numbers for the sample (Snedecor, 1946). The result of this sampling is found in Table 95 (Appendix).

In the fall of 1948 there was a change in the plans, precipitated by the desire on the part of some of the local cooperators to study intensively the operation and management of the school lunches. Since lunch programs were established more extensively in consolidated and independent schools with grades one to twelve, it seemed desirable to draw a larger sample than originally planned from the stratum. The schools in this phase of the study are listed in Table 96 (Appendix).

Since it was not possible to observe every child in the school, the school population was sampled by age-sex groups. In order to cooperate with the plan which was adopted by Ohio and Kansas to study only the 9-10-11-year-old children, it was decided to subdivide each sex into four groups:

1. 6-7-8 years,
2. 9-10-11 years,
3. 12-13-14 years, and
4. 15 years and above.

Not less than three children were randomly drawn from each subdivision. The sample for the whole school was designed to contain about 10 per cent of the school population. The sample was drawn from the school roll as it was obtained from the principal or superintendent. The children under each category were numbered consecutively. The sample of children was drawn by using Snedecor's table of "randomly chosen digits". In Table 99 (Appendix) are listed the number of children chosen in each school.

With the exception of one school the work on this sample of schools, representing the consolidated and independent schools with grades one to twelve of Iowa, was completed during the winter of 1948-1949.

In the fall of 1949 the schools in Population Groups I and II were re-surveyed to check changes that may have occurred in the classification of the schools in the past two years. The schools with supplemental food were listed under schools with no school lunch program. The schools drawn for the new sample were listed in Table 98 (Appendix). In the revised sample of schools the children were chosen by a different plan from that used in the schools with grades one to twelve. This change was brought about by the fact that it was now possible to make a series of measurements of blood constituents known to be helpful in the determination of nutritional status. The staff could only handle 12 to 24 children per day, consequently, two children regardless of size of school population were chosen for each age group and sex. In the schools where a school lunch program was in operation, two sets of children were chosen, one from the group that ate school lunch at least four times a week and another from the group that carried their lunch or went home at noon. In Table 99 (Appendix) are listed the number of schools and number of children in this section of the sample.

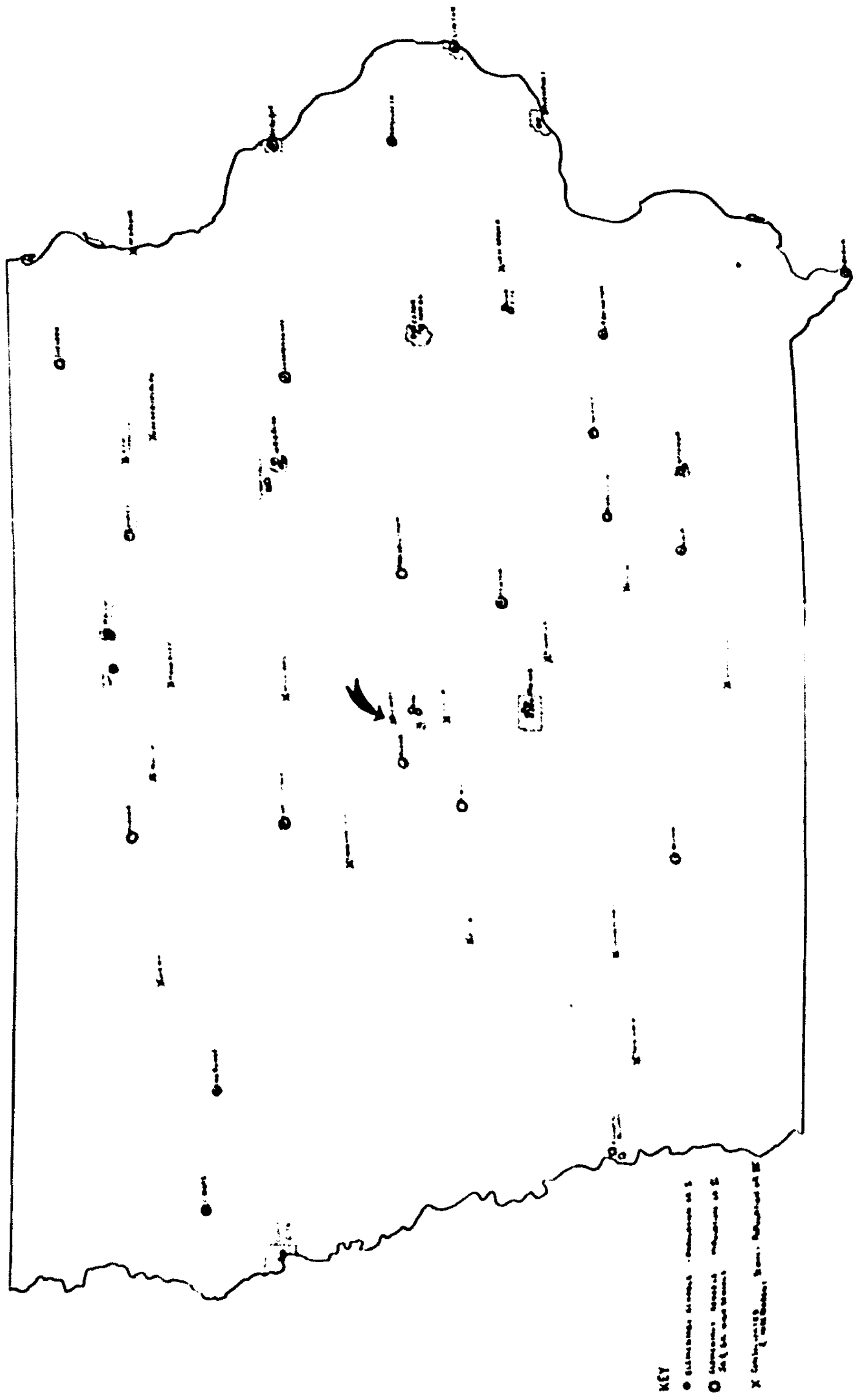
The junior and senior high schools that had a school lunch program could not supply the information on whether or not a student ate regularly at school. Consequently, in this phase of the sample the lunch practice of the child was disregarded and the students were chosen at random from age and sex groups. Two girls and two boys were chosen from all the children in the junior and senior high schools at each of these age classifications: 12 years or below, 13, 14, 15, and 16 years, and 17 years and above.

The schools in the sample were studied as planned, except for the rural elementary, and the urban junior and senior high schools, also one school in the group of the consolidated and independent schools (Figure 1).

As soon as the school sample was drawn, the principal or superintendent was notified either by letter or by a personal visit. The purpose of the survey and the manner that the data would be collected were fully explained to the school authorities. If they approved, arrangements were made to visit the schools. Cooperation was further enhanced by a letter to the administrators of the local schools from the State Director of the School Lunch Program, a past school superintendent well-known throughout the state. Conferences were also held with the State School Superintendent and staff to explain the project and to secure their cooperation.

The name of the child, age, and name and address of parents were obtained for each child in the selected school. After the sample of children was drawn, a letter explaining the study was sent to the parents (see Appendix). A "permission" slip was enclosed with each letter (see

Figure 1. The localities where the 61 schools in the study of the nutritional status of Iowa children were situated.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Appendix). If the parents were willing to have their child participate in the study, they signed the statement and returned the slip.

When the parents refused to have their child participate in the study or a child did not wish to take tests, another child from the same age-sex group was randomly chosen to replace the child who refused to be in the study. During the first year (1948-1949) when the contacts were made primarily by mail the proportion of refusals was large, about 50 per cent. In the following years the families were visited by a member of the research staff, and as a result the number of refusals fell to less than ten per cent.

For the elementary school children in Population Groups I and II, a home visit was made by a research worker, at which time the study was further explained, also the mother was instructed on how to keep a seven-day dietary record. At the same time some information was obtained about the child's family and home environment.

After all the arrangements had been made a research team went to the school to obtain the body measurements and samples of blood. The children were taken from the classroom two or three at a time. First, the blood samples were taken. In order to obtain a blood sample that contained a minimum amount of fat, also a sample that was not influenced by the vitamins of a recent meal, the children came to school either without breakfast, or had a meal of carbohydrate-rich foods like bread and jelly or cereal with sugar. The children in Population Groups I and II were served a breakfast consisting of sweet roll, orange juice and milk as soon as the blood sample was taken.

While part of the workers prepared the blood samples to take back to the laboratory at Iowa State College, Ames, for analysis, the other workers measured the children.

Blood Sampling and Analysis

Hemoglobin determinations as outlined by Ebersole (1949) were made on the children in consolidated and independent schools with grades one to twelve.

During the following winters of 1949-1951 the blood samples were collected according to the technique outlined by Bessey, Lowry, and co-workers. If the school was near Ames, the capillary tubes containing the blood sample were centrifuged and refrigerated. Otherwise the serum was measured into the aliquots needed for the different analyses. The aliquots were placed in serological tubes and sealed tightly with rubber stoppers to prevent evaporation. The aliquots for serum carotenoids were placed in a portable refrigerator containing dry ice. The aliquots of serum for ascorbic acid analyses were deproteinized. A measured amount of supernatant liquid was removed from each sample, put into a clean serological tube, stoppered and frozen. The aliquots of serum for the alkaline phosphatase analysis were placed in the portable refrigerator containing ice. Because the enzyme is slowly inactivated by the carbon dioxide released from the dry ice, regular ice was used to preserve the samples.

The hemoglobin values for the children in Population Groups I and II were determined by measuring the oxyhemoglobin which is formed in the presence of ammonium hydroxide. Since this mixture is not stable over long periods of time, the measured blood was placed in small vials containing four millimeters of distilled water. The vials were stoppered and refrigerated. A known amount of concentrated ammonium hydroxide was added a short time before the samples were read in the Beckman spectrophometer. If the samples were transported to the laboratory on the same day (or within six hours) of collection, the blood was added immediately to a dilute solution of ammonium hydroxide and refrigerated.

The concentrations of the different constituents in the serum were determined by the following techniques:

Serum ascorbic acid -- Lowry, Lopez and Bessey (1945)

Serum carotenoid -- Lowry, Brock and Lopez (1946)

Serum alkaline phosphatase -- Bessey, Lowry and Brock (1946)

The data on each child were complete for most of the nearly 700 children studied in the period from 1949 to 1951. Unfortunately, a blood analysis or a dietary record was not obtainable from a few children. Some children refused to have their finger pricked when it came time for the blood sample to be taken. Others under the stress of the situation did not bleed sufficiently well to provide a large enough sample for all the analyses. Occasionally the children lost their dietary record, or failed to keep a usable record.

Physical Measurements

The children were measured in the late morning just before lunch and after they had emptied their bladders.

The small girls wore their panties, the older girls their brassiere and panties, the small boys their shorts and the older boys their "gym" trunks, when they were weighed and measured. All children were measured in their stocking feet. The small Borg bathroom scales used to weigh the children were checked at the Physics Department of Iowa State College and were certified to weigh correctly up to 275 pounds. Heights were measured against a paper scale which was glued against an upright board placed at right angles to a platform. The scale was prepared by the Iowa Child Welfare Research Station at the University of the State of Iowa. A right-angle headpiece was used to determine the point on the measuring scale which marked the highest point of the child's head. Each child was told to stand up straight, with the heels, hips, shoulders and back of the head touching the board, and to look straight ahead with arms hanging loosely at the sides, and to stand as tall as possible without lifting the heels from the floor. The heights were recorded to the nearest tenth of an inch, and the weights to the nearest half pound. The heights and the weights were charted on the Wetzel Grid (Wetzel, 1941).

Dietary Records

During 1948-1949 children of nine years and older were instructed by a dietitian on how to keep a record of their dietary intake. In the case of the younger children, clear complete instructions were sent home to the mother. During 1949-1951 the dietitian visited the homes of the children who attended the elementary schools to explain to the mothers how the records were to be kept. The high school students followed the instructions and kept their own records. The amounts of food were recorded in household measures.

During the time that the body measurements were made the dietitian reviewed the dietary record with the child to make certain that the dietary information was kept, as requested.

The dietary intakes were recorded by the child during the week that the blood sample was taken. In a few cases where the schedule did not permit such an arrangement, the record was kept the week preceding the time the blood sample was taken.

Dietary Calculations

To obtain an estimate on the size of servings that children at different ages usually ate, a small study was conducted on a group of Ames children whose ages were similar to those of the children in the study. The mother of each child recorded the serving of each food in household measures and in gram weight. From this pilot study it was observed that the size servings could be classified by age groups. The average gram weight was approximately 1/2 the usual adult serving for the 6-, 7- and 8-year-old children; 2/3 the usual adult serving for the 9-, 10- and 11-year-olds, and a full adult serving for the children 12 and above years. An adult serving was determined by the estimates for an average serving listed by Bowes and Church (1946). These estimates were used when a child recorded a serving of a certain food without giving the approximate measure.

Since these dietary data were to be placed on punch cards, the dietary record was translated into terms suitable for punching. The amount of food eaten at each meal every day was listed along with the size servings, number of servings, and the code number for the food item, as well as the code number for the child and the school that he attended. A card was punched for each food that the child ate at each meal.

The food energy and nutrient values for each food was "ganged punched" on these cards later.

The food energy and nutrient value of each food was punched on a "so-called master card". The information on the nutritive value of each food was obtained mainly from the Composition of Foods- Raw, Processed and Prepared (U. S. D. A., 1950) or from Food Values of Portions Commonly Used (Bowes and Church, 1946). When it was necessary recipes were obtained from standard cook books.

The cards containing the child's number, food code and number of servings were sorted, so that all the cards with the same food code and same number of servings were in one pack. This pack, along with the master card, was placed in an I. B. M. duplicator, whereby the nutritive values for the specific food were punched on to the card.

A summary card was punched for the total food energy value and nutritive content of each meal for each child. From this set of cards the total intake of the different nutrients for the week was obtained. The average intake of the different nutrients for each child was calculated on a portable calculator. In turn, these seven-day dietary averages were punched on a card and used in the various calculations as the mean dietary intakes of each child.

Analysis of the Data

To show the central tendency and the variability of the distribution of the data for each age and sex, the mean, standard deviation, standard error of the mean and range were calculated for each age and sex. These calculations were made on the data for the following: dietary intakes, heights, weights, developmental level, and for the concentrations of the blood constituents, hemoglobin, serum carotenoid, serum ascorbic acid, and serum alkaline phosphatase.

The height, weight, developmental level and the different blood constituents for each age-sex group were subdivided into three groups according to the mean and the standard deviation, in order to observe the dietary and blood constituent differences that may exist among children with different levels of physical status and blood constituents in an age-sex group. The three groups were as follows: Group I comprised of the children who were in the minus second or third standard deviations, Group II of the children who were in the plus second or third standard deviations, and Group III of the children within plus or minus one standard deviation. The comparisons among these three groups were based on the mean of the groups.

In order to quantify the comparison in the three groups of developmental levels for each age and sex, the individuals from six to 18 years who were in Group I were pooled and considered in the calculations of the regressions as one group of children with the same characteristic. The same was done for Groups II and III. Consequently, Group I consisted of all the children with the lowest developmental level rating for each age-sex groups from 6 to 18 years; Group II all the children from 6 to 18 years with the highest developmental levels; and Group III with all the children 6 to 18 years with average developmental levels. The regressions of the developmental level on each nutrient and blood constituent were calculated for each group.

NUTRITIVE VALUE OF DIET OF IOWA CHILDREN

> With the growth of the scientific spirit and method and its application to all branches of learning it is not surprising to find that the attempt has been made to record carefully and express in chemical terms the food habits of man in different countries, the underlying idea being that such a summary of data should show the practice of those who were in health, comfort and vigor, whose lives were long and whose offspring were healthy, and that this would be valuable as a guide for others. Such an inference seems natural and reasonable, for it is difficult for those who believe that the human race has developed and improved as it has lived, and has constantly brought itself and its environment more nearly into harmony, to conclude otherwise than that the general customs of a race represent the accumulated wisdom of the ages of experiment and experience which have gone before. (Langworthy, 1911, p. 10).

In this study an analysis was made of the nutrient intake of 1188 Iowa children. The mean daily intake might be expected to represent a reasonably good standard. The children were in sufficiently good health to attend school. The data were collected during a period of economic prosperity (1948-1951).

To obtain an over-all picture of the daily food energy and nutrient value of the diets, the mean, standard deviation, standard error of the mean and the range have been calculated for each sex and yearly age group.

The standard deviation, standard error of the mean and the range are measures of variability. The mean plus or minus the standard deviation gives the limits within which two-thirds of the observations fall. The mean plus or minus the standard error of the mean gives the limits within which one may expect to find the means of other samples drawn from the same population. The range gives the spread of all the observations. From this amount of information one can observe the variability in the data, also whether the distribution is normal or skewed.

The mean nutrient intake of the Iowa children will be evaluated in accordance with the Recommended Dietary Allowances of the National Research Council (1948) for each age and sex. The findings of this study will be contrasted with results of comparable studies from other parts of the United States. So as to make the Iowa data in these instances comparable to the data reported by other investigators, the Iowa data were recalculated into the same age-sex groupings used by other investigators.

Food Energy Value

The mean food energy value of the diets of the boys either exceeded or closely approximated the allowances from 6 to 16 years. Before 12 years the values for food energy were above, and afterwards a little below, the allowances.

In food energy value the diets of the girls were above the allowances until the ninth year. Thereafter the mean food energy values fell below the allowances except at 12, 15 and 18 years. At these ages the means barely met the allowances.

As judged from the standard error of the mean, similar studies on the same population would yield mean daily food energy values within 40 to 150 calories of the means presented in Table 2. The range of the individual observations was extensive for each age and sex. The same observation was noted in the range of the food energy values which Moschette et al. (1952) obtained in Louisiana for the 487 preadolescent children from 8 to 11 years of age. These investigators reported a range of 1164 to 5194 calories. For the similar age-groups and for both sexes the range for the Iowa children was 1056 to 4800 calories. The mean energy values of the diets of the Louisiana children appeared to be a little higher than those of the Iowa children. In Table 3 are tabulated the mean food energy values observed by Tucker et al. (1952) for the diets of the children in certain states in the Northeast Region, by Young and Pilcher (1950) for the children in Groton Township,

Table 2

Mean Daily Food Energy Value of the Diets of Iowa Children

Age yr.	No.	Mean cal.	Standard deviation cal.	Standard error cal.	Range cal.
			Boys		
6	37	2201	344.4	56.6	1545 - 2919
7	56	2166	327.2	43.7	1482 - 3221
8	54	2270	367.3	50.0	1424 - 2834
9	53	2433	468.8	64.4	1076 - 3374
10	60	2417	398.3	51.4	1483 - 3308
11	50	2615	396.8	56.1	1702 - 3743
12	91	2740	725.3	76.0	962 - 4800
13	45	2877	594.6	88.6	1737 - 3977
14	39	3088	543.2	87.0	2082 - 4163
15	32	3252	623.0	110.1	1796 - 4907
16	31	3421	624.4	112.1	2443 - 5007
17	21	3399	680.7	148.5	2159 - 4345
18	17	3439	468.4	113.6	2828 - 4346
			Girls		
6	50	1960	313.6	44.4	1136 - 2573
7	48	1987	355.1	51.3	1140 - 2485
8	43	2025	345.1	52.6	1160 - 2559
9	62	2282	322.2	40.9	1324 - 2891
10	62	2280	359.4	45.6	1538 - 3143
11	58	2262	430.5	56.5	1511 - 3359
12	84	2568	501.3	54.7	1448 - 4145
13	44	2471	576.1	86.9	1524 - 3472
14	37	2487	500.5	82.3	1639 - 3887
15	39	2594	395.0	63.2	1746 - 3172
16	36	2312	437.0	72.8	1429 - 3401
17	26	2374	632.7	124.1	1314 - 3328
18	13	2420	469.1	130.1	1454 - 3024

Table 3

Mean Daily Food Energy Value of the Diets of Children of Iowa and of Other Places

Age group	7-9 years		10-12 years		13-15 years		16-18 years	
Places	No.	Mean cal.	No.	Mean cal.	No.	Mean cal.	No.	Mean cal.
				Boys				
Iowa	163	2287	201	2612	116	3051	69	3419
New York[a] Groton Twp	34	1569	29	2028	25	2193	19	2557
New York[b]	43	2150	43	2623	104	3099	9	3279
Maine[b]	--	--	5	1920	85	2976	19	3304
Rhode Island[b]	--	--	--	--	11	2667	48	2969
West Virginia[b]	--	--	--	--	--	--	101	2901
Tennessee[c]	51	1726	58	1855	64	2494	69	2723
				Girls				
Iowa	153	2117	204	2393	120	2516	75	2321
New York[a] Groton Twp	23	1697	10	1849	20	2026	24	2275
New York[b]	44	1899	53	2173	113	2614	8	2145
Maine[b]	--	--	7	2227	123	2439	27	2213
Rhode Island[b]	--	--	--	--	45	2223	189	2004
West Virginia[b]	--	--	--	--	--	--	131	2035
Tennessee[c]	51	1726	58	1855	63	1691	65	1975

[a]Young and Pilcher (1950).

[b]Tucker, et al. (1952).

[c]Youmans, et al. (1943).

New York State, and by Youmans et al. (1943) on a group of Tennessee children.

The mean food energy values of the diets of Iowa children tended to be among the highest values, and may be contrasted sharply at most ages with comparable figures from Tennessee which tended to be the lowest of the group.

Beal, Burke and Stuart (1945) presented the mean food energy value of the children that they had studied repeatedly over a period of 15 years by means of diet histories. The range of the mean energy food value for the children from 6 to 10 years of age varied from 1932 to 2345 calories for boys and from 1897 to 2168 calories for girls.

In general the mean food energy value of the diets of Iowa children was higher, and met the allowances more closely than the values that have been observed for the diets of children of the same age in other places of the United States where similar studies have been conducted.

Protein Value

The mean daily protein content of the diets of the boys was greater than the allowances through the entire age range. The girls from 6 to 13 years either had protein intakes greater than or nearly equal to the allowances.

From 13 to 18 years the protein content of the diet tended to be less than the recommendations.

The protein intake of these children varied widely among individuals as well as between ages and sexes (see Table 4). The widest range of intakes was found in the 11-, 12- and 14-year-old boys and 12- and 17-year-old girls. In repeated studies in the same population the mean protein intake will fall within 2 to 4 grams of the mean obtained for each age and sex in this study.

The 487 preadolescent Louisiana children (Moschette et al., 1952) had diets with a mean daily protein content of 89 grams. The range was 42.7 to 221.7 grams; the corresponding range for the protein intake of Iowa children was 26 to 134 grams. The Iowa children seemed to have smaller protein intakes than did the Louisiana children.

The mean daily protein content of the diets of the children in Iowa was either higher than, or in the range of the values obtained by Tucker et al. (1952) and Young and Pilcher (1950). The Iowa children of all ages and both sexes seemed to have higher intakes of protein than the Tennessee children (see Table 5).

Table 4

Mean Daily Protein Content of the Diets of Iowa Children

Age yr.	No.	Mean gm.	Standard deviation gm.	Standard error gm.	Range gm.
			Boys		
6	37	67	12.2	2.0	47 - 95
7	56	65	11.4	1.5	48 - 97
8	54	71	12.6	1.7	42 - 102
9	53	74	17.0	2.3	26 - 111
10	60	74	12.6	1.6	38 - 104
11	50	79	15.9	2.2	45 - 134
12	91	85	22.6	2.4	44 - 154
13	45	86	18.8	2.8	56 - 130
14	39	91	17.4	2.8	66 - 154
15	32	93	17.2	3.0	50 - 112
16	31	99	20.8	3.7	72 - 140
17	21	105	17.2	3.8	76 - 132
18	17	102	21.6	5.2	75 - 148
			Girls		
6	50	60	11.1	1.6	38 - 81
7	48	61	11.4	1.6	35 - 80
8	43	63	12.0	1.8	36 - 86
9	62	70	9.9	1.2	48 - 89
10	62	68	13.5	1.7	42 - 108
11	58	69	15.0	2.0	43 - 106
12	84	80	15.1	1.6	44 - 128
13	44	74	19.7	2.9	40 - 113
14	37	75	17.0	2.8	44 - 112
15	39	75	14.0	2.2	46 - 109
16	36	69	13.7	2.3	32 - 90
17	26	73	21.9	4.3	32 - 138
18	13	72	14.0	3.9	44 - 95

Table 5

Mean Daily Protein Content of the Diets of Children of Iowa and Other Places

Age group	7-9 years		10-12 years		13-15 years		16-18 years	
Places	No.	Mean gm.	No.	Mean gm.	No.	Mean gm.	No.	Mean gm.
Boys								
Iowa	163	70	201	80	116	90	69	102
New York[a] Groton Twp	34	73.7	29	84.9	25	106.7	19	97.6
New York[b]	43	72.6	43	87.6	104	101.9	9	97.1
Maine[b]	--	--	5	64.5	85	90.9	19	94.5
Rhode Island[b]	--	--	--	--	11	89.7	48	94.8
West Virginia[b]	--	--	--	--	--	--	101	93.6
Tennessee[c]	51	56	58	57	64	83	69	87
Girls								
Iowa	153	65	204	73	120	74	75	71
New York[a] Groton Twp	23	68.8	10	70.0	20	62.2	24	65.1
New York[b]	44	63.8	53	72.8	113	85.0	8	67.5
Maine[b]	--	--	7	70.2	123	76.8	27	68.2
Rhode Island[b]	--	--	--	--	45	70.8	189	63.5
West Virginia[b]	--	--	--	--	--	--	131	66.1
Tennessee[c]	51	56	58	57	63	48	65	60

[a]Young and Pilcher (1950).

[b]Tucker, et al. (1952).

[c]Youmans, et al. (1943).

Fat Value

In Table 6 for all ages and both sexes are tabulated the mean, standard deviation, standard error of the mean and range of the calculated fat content of the diets of Iowa children. The mean intake of dietary fat increased with age for the boys and the girls to 18 and 12 years, respectively.

For each age and sex approximately 43 per cent of the mean food energy value of the diets came from fat.

The knowledge of the role of fat in human nutrition is meager. Deuel (1950) stated:

> If we apply the results of the experiments on rats to the human picture, then a rather generous fat intake in man is indicated. The optimum level of fat in the diet on this basis would be approximately 30 per cent by weight or 50 per cent of the calories. (p. 258)

The percentage of calories from fat in the diets of Iowa children approximated the figure proposed by Deuel.

Carbohydrate Value

The mean carbohydrate content of the diets of Iowa children and the standard deviation, standard error of the mean and range for each age and sex are listed in Table 7.

Table 6

Mean Daily Fat Content of Diets of Iowa Children

Age yr.	No.	Mean gm.	Standard deviation gm.	Standard error gm.	Range gm.
			Boys		
6	37	104	19.2	3.2	62 - 146
7	56	104	18.7	2.5	72 - 157
8	54	110	20.4	2.8	69 - 160
9	53	117	26.7	3.7	41 - 166
10	60	117	24.2	3.1	60 - 177
11	50	125	21.1	3.0	81 - 177
12	91	133	36.3	3.8	54 - 227
13	45	138	31.0	4.6	84 - 212
14	39	150	29.6	4.7	106 - 227
15	32	159	31.6	5.6	88 - 227
16	31	167	38.8	7.0	111 - 273
17	21	171	34.3	7.5	88 - 214
18	17	175	26.5	6.4	132 - 222
			Girls		
6	50	94	18.3	2.6	51 - 134
7	48	99	20.2	2.9	66 - 138
8	43	96	18.4	2.8	51 - 134
9	62	110	16.9	2.2	66 - 146
10	62	107	16.7	2.1	64 - 158
11	58	109	24.7	3.2	68 - 166
12	84	122	25.4	2.7	54 - 189
13	44	116	28.4	4.3	76 - 190
14	37	120	26.3	4.3	84 - 186
15	39	126	21.2	3.4	84 - 164
16	36	112	22.0	3.7	57 - 157
17	26	114	35.5	6.9	38 - 188
18	13	118	24.1	6.7	64 - 150

Table 7

Mean Daily Carbohydrate Content of Diets of Iowa Children

Age yr.	No.	Mean gm.	Standard deviation gm.	Standard error gm.	Range gm.
			Boys		
6	37	260	54.1	8.9	195 - 351
7	56	253	42.4	5.7	142 - 319
8	54	260	47.8	6.5	159 - 351
9	53	289	53.1	7.3	161 - 412
10	60	283	49.6	6.4	174 - 410
11	50	310	52.4	7.4	170 - 434
12	91	317	92.0	9.6	82 - 582
13	45	336	77.9	11.6	203 - 537
14	39	361	76.3	12.2	221 - 537
15	32	378	83.5	14.8	196 - 487
16	31	396	67.6	12.1	280 - 584
17	21	381	100.0	21.8	193 - 539
18	17	377	65.9	16.0	267 - 520
			Girls		
6	50	226	38.0	5.4	130 - 327
7	48	220	46.3	6.7	88 - 284
8	43	240	49.2	7.5	125 - 358
9	62	266	43.6	5.5	138 - 361
10	62	278	52.3	6.6	189 - 383
11	58	264	51.9	6.8	164 - 392
12	84	302	66.6	7.3	169 - 515
13	44	296	73.6	11.1	177 - 546
14	37	290	62.0	10.2	203 - 417
15	39	303	53.2	8.5	174 - 382
16	36	270	62.2	10.4	131 - 352
17	26	275	66.5	13.0	152 - 378
18	13	282	57.7	16.0	177 - 351

There was a tendency for the boys to increase the carbohydrate intake with age up to 16 years. The girls showed a similar tendency to 16 years, but after that age they curtailed their use of this foodstuff. The variability was large for all ages and for both sexes as may be noted from the ranges.

About 46 per cent of the food energy value came from carbohydrates. This percentage was within the range (40 to 50 per cent) usually found in the average American diet.

Calcium Value

The 6- to 8-year-old and the 17-year-old boys had diets with mean daily calcium content greater than the allowances; otherwise the boys had diets with calcium values below the recommendations. The mean daily calcium content of the diets of girls were below the allowances except for the 8-year-old girls, whose intakes barely met the recommendations.

In general the mean calcium contents of the diets of the boys of Iowa increased with age (Table 8). To 12 years of age the calcium intake of the girls varied, from 13 to 18 years there was a definite decline in the mean calcium intakes. As may be noted from range the individual intakes

Table 8

Mean Daily Calcium Content of the Diets of Iowa Children

Age yr.	No.	Mean mg.	Standard deviation mg.	Standard error mg.	Range mg.
			Boys		
6	37	1061	302.6	49.7	516 - 1854
7	56	1026	265.5	35.5	529 - 1733
8	54	1124	293.2	39.9	430 - 1721
9	53	1093	307.2	42.2	362 - 1870
10	60	1042	286.5	37.0	395 - 1723
11	50	1128	281.1	39.8	546 - 1525
12	91	1133	398.2	41.7	164 - 2437
13	45	1139	442.3	65.9	506 - 2099
14	39	1131	354.5	56.8	534 - 2060
15	32	1176	365.9	64.7	257 - 2178
16	31	1314	370.3	66.5	730 - 2046
17	21	1441	497.7	108.6	765 - 2422
18	17	1182	344.4	83.5	571 - 1707
			Girls		
6	50	918	260.8	36.9	376 - 1622
7	48	877	269.1	38.8	406 - 1437
8	43	1009	245.6	37.5	504 - 1568
9	62	956	246.5	31.3	491 - 1460
10	62	936	293.2	37.2	455 - 2046
11	58	1004	287.4	37.7	532 - 1725
12	84	1071	307.0	33.5	434 - 1882
13	44	994	415.9	62.7	423 - 2685
14	37	987	324.8	53.4	412 - 1744
15	39	899	301.6	48.3	463 - 1735
16	36	811	295.6	49.3	168 - 1398
17	26	838	315.8	61.9	229 - 1853
18	13	809	261.8	72.6	406 - 1212

varied extensively. In the various age-sex groups the difference between the lowest and highest value of intakes was seldom less than a thousand milligrams. However, a similar study of the calcium intake of this population of children might be expected to yield a mean calcium intake within 30 to 100 milligrams of the present means.

For the Louisiana children (Moschette et al., 1950), the mean calcium content of the food eaten daily was 1202 milligrams with the standard deviation of 550 milligrams and a range of 350 to 3380 milligrams. The variability was equally as large as observed in the Iowa values.

The mean calcium content of the food eaten by the Iowa boys tended to be lower than the values obtained by Tucker et al. (1952) except for the Maine 10-12-year-old boys and the West Virginia 16-20-year-old boys. The boys in Groton Township (Young and Pilcher, 1950) had higher dietary calcium than that noted for the boys in Iowa (see Table 9).

The Iowa girls had lower mean daily calcium intakes than were noted for the girls of corresponding ages in the Northeast Region, but with the exception of the 7- to 9-year-old girls, the Groton Township girls had lower dietary calcium values than the Iowa children.

Table 9

Mean Daily Calcium Content of the Diets of Children of Iowa and of Other Places

Age group	7-9 years		10-12 years		13-15 years		16-18 years	
Places	No.	Mean mg.	No.	Mean mg.	No.	Mean mg.	No.	Mean mg.
Boys								
Iowa	163	1080	201	1104	116	1141	69	1319
New York[a] Groton Twp	34	1100	29	1318	25	1606	19	1292
New York[b]	43	1280	43	1540	104	1560	9	1300
Maine[b]	--	--	5	980	85	1370	19	1300
Rhode Island[b]	--	--	--	--	11	1300	48	1330
West Virginia[b]	--	--	--	--	--	--	101	1250
Girls								
Iowa	153	946	204	1011	120	961	75	820
New York[a] Groton Twp	23	1177	10	936	20	910	24	702
New York[b]	44	1140	53	1180	113	1420	8	930
Maine[b]	--	--	7	1210	123	1090	27	1000
Rhode Island[b]	--	--	--	--	45	960	189	890
West Virginia[b]	--	--	--	--	--	--	131	920

[a]Young and Pilcher (1950).

[b]Tucker, *et al.* (1952).

Iron Value

The mean daily iron intakes of the Iowa boys fluctuated about the allowances throughout the age range (Table 10). The mean iron values of the diets of Iowa girls were below the allowances except for the 7-year-old girls, whose diets barely met the recommendations.

The mean iron values for the diets of Iowa boys were greater than for the girls. The range of the mean iron values for the girls of all ages varied from 9 to 12 milligrams. The mean iron intakes of other samples of children drawn from this population will vary most of the time within 0.2 to 0.9 milligrams from the means obtained in this study.

The pre-adolescent children in Louisiana (Moschette <u>et</u> <u>al</u>., 1950) had mean daily intakes of iron of 11.96 milligrams with a standard deviation of 3.56 milligrams, and the range was from 6.0 to 27.7 milligrams. The Iowa children for comparable ages had a range 3.8 to 18.1 milligrams and appeared to have a lower mean iron intake than had the Louisiana children.

In Table 11 are tabulated the mean iron values obtained by Tucker <u>et</u> <u>al</u>. (1952) for the diets of the children in the Northeast Region, and by Young and Pilcher (1950) for the diets of the children in Groton Township.

Table 10

Mean Daily Iron Content of the Diets of Iowa Children

Age yr.	No.	Mean mg.	Standard deviation mg.	Standard error mg.	Range mg.
			Boys		
6	37	10	1.5	0.2	7 - 14
7	56	10	1.7	0.2	6 - 14
8	54	10	2.0	0.3	6 - 15
9	53	11	2.7	0.4	4 - 18
10	60	11	2.0	0.2	8 - 18
11	50	12	2.2	0.3	7 - 18
12	91	13	3.6	0.4	6 - 25
13	45	14	3.3	0.5	8 - 20
14	39	14	2.7	0.4	8 - 21
15	32	15	4.5	0.8	7 - 23
16	31	16	3.4	0.6	10 - 22
17	21	16	3.4	0.7	7 - 22
18	17	15	2.8	0.7	12 - 21
			Girls		
6	50	9	1.4	0.2	6 - 12
7	48	9	1.6	0.2	6 - 12
8	43	9	1.8	0.3	5 - 14
9	62	11	1.9	0.2	7 - 15
10	62	11	2.0	0.2	7 - 18
11	58	10	2.1	0.3	6 - 15
12	84	12	2.5	0.3	6 - 19
13	44	11	2.9	0.4	5 - 17
14	37	12	2.3	0.4	8 - 18
15	39	10	2.4	0.4	8 - 18
16	36	11	2.6	0.4	6 - 16
17	26	11	3.1	0.6	6 - 17
18	13	11	2.4	0.7	6 - 15

Table 11

Mean Daily Iron Content of the Diets of Children of Iowa and of Other Places

Age group	7-9 years		10-12 years		13-15 years		16-18 years	
Places	No.	Mean mg.	No.	Mean mg.	No.	Mean mg.	No.	Mean mg.
Boys								
Iowa	163	10	201	12	116	14	69	16
New York[a] Groton Twp	34	10.9	29	13.6	25	18.7	19	17.3
New York[b]	43	10.3	43	13.3	104	16.4	9	19.3
Maine[b]	--	--	5	12.0	85	17.0	19	18.5
Rhode Island[b]	--	--	--	--	11	14.5	48	15.4
West Virginia[b]	--	--	--	--	--	--	101	15.3
Girls								
Iowa	153	10	204	11	120	12	75	11
New York[a] Groton Twp	23	10.3	10	10.6	20	10.0	24	11.1
New York[b]	44	9.2	53	11.3	113	13.0	8	11.3
Maine[b]	--	--	7	12.2	123	14.1	27	13.1
Rhode Island[b]	--	--	--	--	45	11.7	189	10.6
West Virginia[b]	--	--	--	--	--	--	131	10.5

[a]Young and Pilcher (1950).

[b]Tucker, et al. (1952).

With the exception of the oldest age-group, the Iowa boys tended to have diets with mean iron values that were lower than those for the diets of the boys in the Northeast Region. The mean iron intakes of the Iowa girls tended to be similar to the intakes of the girls in the Northeast Region. The boys in Groton Township had diets with a higher iron content than that of the diets of the Iowa boys. With the exception of 7- to 9-year-old girls the Iowa girls had higher intakes of iron than had the Groton Township girls.

Vitamin A Value

The mean vitamin A values of the daily food consumption were greater than the allowances for all ages of both sexes.

For each age and sex the distribution was skewed to the right, because there were some very high values (see Table 12).

The mean vitamin A value of the daily diets of the Iowa children tended to be higher than those noted for the children in the Northeast Region (see Table 13). The Iowa boys had diets lower in vitamin A value than had the boys from Groton Township, whereas the vitamin A intake of the girls in the two studies showed no consistent relationship throughout the ages compared.

Table 12

Mean Daily Vitamin A Value of the Diets of Iowa Children

Age yr.	No.	Mean I.U.	Standard deviation I.U.	Standard error I.U.	Range I.U.
			Boys		
6	37	5671	3077	506	2144 - 16769
7	56	5835	2455	328	2077 - 13260
8	54	6865	4430	603	2192 - 28670
9	53	8427	5481	753	1544 - 26396
10	60	7541	4262	550	2197 - 17978
11	50	7637	5375	760	2670 - 32242
12	91	8342	6206	651	1009 - 33044
13	45	8303	6217	927	2278 - 34266
14	39	9037	5665	907	2823 - 29919
15	32	9800	7210	1274	2314 - 34307
16	31	9180	4456	800	2833 - 19542
17	21	8796	4300	938	3308 - 21804
18	17	8862	5205	1263	4020 - 20898
			Girls		
6	50	6175	3778	534	2589 - 14588
7	48	5961	3606	521	1498 - 17548
8	43	6208	4232	646	1945 - 22774
9	62	6977	3851	489	1743 - 20621
10	62	8010	6407	814	1295 - 35282
11	58	6458	3378	444	1967 - 15508
12	84	8315	4982	544	1842 - 30506
13	44	6773	3645	550	2202 - 16700
14	37	7219	4324	711	2581 - 23477
15	39	6943	4707	754	2263 - 20065
16	36	5771	3620	603	1228 - 15984
17	26	7140	3912	767	1745 - 15911
18	13	6596	4210	1168	2376 - 15860

Table 13

Mean Daily Vitamin A Value of the Diets of Children of Iowa and of Other Places

Age group	7-9 years		10-12 years		13-15 years		16-18 years	
Places	No.	Mean I.U.	No.	Mean I.U.	No.	Mean I.U.	No.	Mean I.U.
Boys								
Iowa	163	7019	201	7927	116	8963	69	8985
New York[a] Groton Twp	34	7509	29	11072	25	14824	19	11189
New York[b]	43	5979	43	8109	104	7982	9	8044
Maine[b]	--	--	5	4650	85	8790	19	10850
Rhode Island[b]	--	--	--	--	11	6810	48	6790
West Virginia[b]	--	--	--	--	--	--	101	6840
Girls								
Iowa	153	6357	204	7694	120	6916	75	6389
New York[a] Groton Twp	23	6832	10	5354	20	5992	24	6541
New York[b]	44	5893	53	6283	113	7132	8	6200
Maine[b]	--	--	7	6310	123	8340	27	6450
Rhode Island[b]	--	--	--	--	45	5490	189	6080
West Virginia[b]	--	--	--	--	--	--	131	6390

[a]Young and Pilcher (1950).

[b]Tucker, et al. (1952).

Moschette <u>et al</u>. (1952) reported a mean daily intake of vitamin A value of 6181 I.U. with a standard deviation 3946 I.U. for the preadolescent children in different areas of Louisiana, the range was 1109 to 32030 I.U. For Iowa children of the same age group the range was 1295 to 35282 I.U.

Ascorbic Acid Value

The mean ascorbic acid values for the diets of the Iowa boys were equal to, or higher than, the allowances to 16 years of age, then the mean values were below the recommendations. At all ages the mean daily ascorbic acid intakes of the girls were higher than the allowances.

In Table 14 it may be observed that the distribution was skewed to the right denoting that there were some high ascorbic acid values. The variation in mean daily ascorbic acid intakes of children was large, as may be noted from the ranges for each age and sex.

Moschette <u>et al</u>. (1952) reported a mean ascorbic acid value of 80 milligrams and a standard deviation 46.3 milligrams for the diets of the Louisiana children. The range was 12 to 277 milligrams. The range for Iowa children of similar ages was 19 to 205 milligrams.

Table 14

Mean Daily Ascorbic Acid Content of the Diets of Iowa Children

Age yr.	No.	Mean mg.	Standard deviation mg.	Standard error mg.	Range mg.
			Boys		
6	37	81	30.1	4.9	28 - 180
7	56	72	29.2	3.9	21 - 133
8	54	78	32.1	4.4	25 - 187
9	53	84	30.2	4.1	15 - 144
10	60	77	29.1	3.8	19 - 153
11	50	85	33.8	4.8	26 - 170
12	91	84	40.1	4.2	27 - 218
13	45	97	51.7	7.7	20 - 291
14	39	91	41.5	6.6	45 - 244
15	32	97	48.0	8.5	19 - 221
16	31	111	39.0	7.0	38 - 226
17	21	102	40.8	8.9	51 - 202
18	17	86	46.1	11.1	39 - 212
			Girls		
6	50	66	28.6	4.0	22 - 151
7	48	77	34.7	5.0	25 - 223
8	43	76	32.1	4.9	27 - 144
9	62	82	29.2	3.7	33 - 161
10	62	86	38.7	4.9	28 - 205
11	58	80	27.8	3.6	30 - 159
12	84	81	32.0	3.5	25 - 181
13	44	76	32.6	4.9	17 - 159
14	37	120	26.3	4.3	20 - 158
15	39	126	21.2	3.4	30 - 191
16	36	112	22.0	3.7	26 - 196
17	26	87	36.5	7.2	28 - 178
18	13	92	33.8	9.4	43 - 154

The mean daily ascorbic acid content of the diets of Iowa boys tended to be slightly higher than the corresponding values reported by Tucker et al. (1952), but bore no consistent relationship with the figures obtained by Young and Pilcher (1950). The Iowa girls had higher mean daily intakes of ascorbic acid than had most of the other groups of girls (see Table 15).

Thiamine Value

In thiamine content the diets of Iowa boys either surpassed or approximately met the allowances for this nutrient. The girls had mean dietary thiamine intakes that were above or equal to the allowances to nine years, but from 10 to 18 years the Iowa girls usually had mean daily intakes of thiamine which were less than the allowances.

Table 16 shows that the boys tended to increase the mean thiamine value of the diets with age, whereas the girls maintained little change in thiamine intake throughout the age range. The variation among the individual observations was not extensive, as may be observed from the standard deviation and standard error of the mean.

The mean daily intake of thiamine of the Louisiana children was 1.27 milligram with a standard deviation of

Table 15

Mean Daily Ascorbic Acid Content of the Diets of Children of Iowa and Other Places

Age group	7-9 years		10-12 years		13-15 years		16-18 years	
Places	No.	Mean mg.	No.	Mean mg.	No.	Mean mg.	No.	Mean mg.
Boys								
Iowa	163	78	201	82	116	95	69	102
New York[a] Groton Twp	34	69	29	85	25	98	19	98
New York[b]	43	71.4	43	79.9	104	90.2	9	100.0
Maine[b]	--	--	5	69.5	85	80.6	19	80.0
Rhode Island[b]	--	--	--	--	11	67.1	48	82.0
West Virginia[b]	--	--	--	--	--	--	101	77.2
Girls								
Iowa	153	79	204	82	120	83	75	90
New York[a] Groton Twp	23	58	10	81	20	70	24	63
New York[b]	44	66.8	53	71.8	113	87.1	8	64.9
Maine[b]	--	--	7	89.5	123	77.5	27	56.2
Rhode Island[b]	--	--	--	--	45	71.8	189	73.8
West Virginia[b]	--	--	--	--	--	--	131	73.4

[a]Young and Pilcher (1950).

[b]Tucker, et al. (1952).

Table 16

Mean Daily Thiamine Content of the Diets of Iowa Children

Age yrs.	No.	Mean mg.	Standard deviation mg.	Standard error mg.	Range mg.
			Boys		
6	37	1.1	0.19	0.03	0.6 - 1.4
7	56	1.0	0.20	0.03	0.6 - 1.5
8	54	1.1	0.20	0.03	0.6 - 1.5
9	53	1.1	0.25	0.03	0.6 - 1.7
10	60	1.1	0.21	0.03	0.7 - 1.6
11	50	1.2	0.25	0.04	0.8 - 1.9
12	91	1.3	0.38	0.04	0.6 - 2.6
13	45	1.4	0.30	0.04	0.7 - 2.0
14	39	1.5	0.30	0.05	0.9 - 2.0
15	32	1.5	0.36	0.06	0.6 - 2.3
16	31	1.6	0.34	0.06	1.2 - 2.5
17	21	1.6	0.34	0.07	0.9 - 2.2
18	17	1.7	0.44	0.11	1.1 - 2.4
			Girls		
6	50	1.0	0.17	0.02	0.6 - 1.3
7	48	1.0	0.21	0.03	0.6 - 1.5
8	43	1.0	0.17	0.03	0.6 - 1.3
9	62	1.1	0.19	0.02	0.8 - 1.5
10	62	1.1	0.21	0.03	0.7 - 1.6
11	58	1.1	0.25	0.03	0.7 - 1.7
12	84	1.2	0.25	0.02	0.7 - 1.9
13	44	1.2	0.31	0.05	0.6 - 1.7
14	37	1.2	0.28	0.04	0.6 - 1.8
15	39	1.2	0.28	0.04	0.6 - 1.9
16	36	1.2	0.29	0.05	0.7 - 1.9
17	26	1.1	0.31	0.06	0.5 - 1.6
18	13	1.2	0.28	0.08	0.8 - 1.6

0.32 milligram and a range of 0.56 to 1.91 milligrams. In comparison, the diets of the Iowa children ranged from 0.6 to 2.6 milligrams in thiamine content.

The mean daily thiamine content of the diets of children, as reported in other studies, was not much different from the values obtained for the diets of Iowa children (see Table 17).

Riboflavin Value

The diets of Iowa boys contained more riboflavin, as shown by the daily means, than is recommended at the various ages. The diets of Iowa girls contained amounts of riboflavin that were greater than or equal to the allowances.

The mean daily riboflavin content of the diets of the boys increased with age (see Table 18). The mean daily riboflavin content of the diets of the girls tended to increase from 6 to 12 years; after 12 years there was a decrease to values equal to those of the younger girls.

The mean daily riboflavin intake of the Louisiana children, 8 to 11 years of age, was 2.23 milligrams with a standard deviation of 0.55 milligram, and a range of 0.91 to 4.98 milligrams (Moschette *et al*. 1952).

Table 17

Mean Daily Thiamine Content of the Diets of Children of Iowa and of Other Places

Age group	7-9 years		10-12 years		13-15 years		16-18 years	
Places	No.	Mean mg.	No.	Mean mg.	No.	Mean mg.	No.	Mean mg.
Boys								
Iowa	163	1.1	201	1.2	116	1.4	69	1.6
New York[a] Groton Twp	34	1.23	29	1.46	25	1.93	19	1.81
New York[b]	43	1.20	43	1.50	104	1.72	9	1.85
Maine[b]	--	--	5	1.22	85	1.66	19	1.75
Rhode Island[b]	--	--	--	--	11	1.44	48	1.59
West Virginia[b]	--	--	--	--	--	--	101	1.59
Girls								
Iowa	153	1.1	204	1.2	120	1.2	75	1.2
New York[a] Groton Twp	23	1.09	10	1.19	20	1.14	24	1.03
New York[b]	44	1.08	53	1.22	113	1.41	8	1.10
Maine[b]	--	--	7	1.19	123	1.36	27	1.18
Rhode Island[b]	--	--	--	--	45	1.20	189	1.04
West Virginia[b]	--	--	--	--	--	--	131	1.12

[a]Young and Pilcher (1950).

[b]Tucker, et al. (1952).

Table 18

Mean Daily Riboflavin Content of the Diets of Iowa Children

Age yr.	No.	Mean mg.	Standard deviation mg.	Standard error mg.	Range mg.
			Boys		
6	37	1.9	0.48	0.08	1.2 - 3.0
7	56	1.8	0.44	0.06	1.0 - 3.0
8	54	2.0	0.47	0.06	1.0 - 3.3
9	53	2.0	0.62	0.08	0.9 - 4.1
10	60	2.0	0.52	0.07	0.9 - 3.0
11	50	2.1	0.50	0.07	1.2 - 3.6
12	91	2.2	0.75	0.08	0.5 - 4.8
13	45	2.2	0.75	0.11	1.0 - 4.4
14	39	2.2	0.58	0.09	1.5 - 3.4
15	32	2.5	0.80	0.14	0.8 - 4.8
16	31	2.5	0.61	0.11	1.5 - 3.6
17	21	2.7	0.60	0.13	1.7 - 3.8
18	17	2.5	0.81	0.20	1.4 - 4.3
			Girls		
6	50	1.7	0.45	0.06	0.9 - 3.1
7	48	1.6	0.48	0.07	0.8 - 2.9
8	43	1.8	0.48	0.07	1.1 - 3.2
9	62	1.8	0.46	0.06	1.0 - 2.9
10	62	1.8	0.58	0.07	1.0 - 3.0
11	58	1.9	0.52	0.07	1.0 - 3.1
12	84	2.0	0.51	0.06	0.8 - 3.7
13	44	1.8	0.59	0.09	0.9 - 3.7
14	37	1.9	0.68	0.11	0.8 - 3.7
15	39	1.8	0.47	0.07	1.2 - 3.0
16	36	1.6	0.47	0.07	0.6 - 2.6
17	26	1.7	0.56	0.11	0.6 - 2.4
18	13	1.6	0.39	0.11	0.9 - 2.2

The mean riboflavin content of the diets of Iowa boys and girls compared favorably with the values of the children in the Northeast Region (see Table 19). The 10- to 12-year-old boys of Maine and the 13- to 15-year-old boys of Rhode Island had diets with less riboflavin than had the children in the other groups. The boys in Groton Township had higher mean intakes of riboflavin than had the Iowa boys. The girls of Iowa and of Groton Township had similar mean riboflavin intakes.

Niacin Value

The Iowa children had mean dietary niacin intakes that either exceeded or met the allowances.

The variation of the mean daily intakes of niacin among individuals was not great for the diets of the Iowa children (see Table 20). The mean niacin values of the diets of the boys of all ages and of the girls from 6 to 12 years increased with age. The girls from 13 to 18 years had the average of 13 milligrams of niacin in their daily diets.

The Louisiana children had a mean intake of 14.59 milligrams of niacin and a standard deviation of 4.3 milligrams and a range of 5.43 to 35.55 milligrams (Moschette

Table 19

Mean Daily Riboflavin Content of the Diets of Children of Iowa and of Other Places

Age group	7-9 years		10-12 years		13-15 years		16-18 years	
Places	No.	Mean mg.	No.	Mean mg.	No.	Mean mg.	No.	Mean mg.
Boys								
Iowa	163	2.0	201	2.1	116	2.3	69	2.6
New York[a] Groton Twp	34	2.01	29	2.47	25	3.00	19	2.37
New York[b]	43	2.19	43	2.64	104	2.79	9	2.46
Maine[b]	--	--	5	1.77	85	2.54	19	2.70
Rhode Island[b]	--	--	--	--	11	1.83	48	2.36
West Virginia[b]	--	--	--	--	--	--	101	2.32
Girls								
Iowa	153	1.8	204	1.9	120	1.9	75	1.6
New York[a] Groton Twp	23	1.95	10	1.93	20	1.66	24	1.67
New York[b]	44	1.98	53	2.09	113	2.46	8	1.72
Maine[b]	--	--	7	2.12	123	2.05	27	1.80
Rhode Island[b]	--	--	--	--	45	1.71	189	1.63
West Virginia[b]	--	--	--	--	--	--	131	1.66

[a]Young and Pilcher (1950).

[b]Tucker, _et al._ (1952).

Table 20

Mean Daily Niacin Content of the Diets of Iowa Children

Age yr.	No.	Mean mg.	Standard deviation mg.	Standard error mg.	Range mg.
			Boys		
6	37	11	2.0	0.32	7 - 14
7	56	11	2.5	0.33	6 - 17
8	54	12	2.3	0.32	7 - 17
9	53	13	3.0	0.41	6 - 20
10	60	13	3.1	0.40	8 - 21
11	50	13	3.7	0.52	8 - 24
12	91	15	4.1	0.43	5 - 24
13	45	15	3.6	0.54	7 - 24
14	39	16	3.5	0.56	11 - 29
15	32	17	4.7	0.82	7 - 26
16	31	17	3.8	0.67	11 - 23
17	21	17	2.8	0.61	10 - 22
18	17	18	4.1	0.98	12 - 25
			Girls		
6	50	10	1.8	0.26	8 - 12
7	48	10	2.0	0.30	7 - 14
8	43	10	2.2	0.34	6 - 16
9	62	12	2.2	0.28	7 - 21
10	62	12	2.4	0.31	8 - 18
11	58	12	2.8	0.37	6 - 21
12	84	14	2.9	0.32	9 - 21
13	44	13	3.6	0.54	6 - 20
14	37	13	2.6	0.44	8 - 19
15	39	14	3.2	0.51	7 - 21
16	36	12	2.6	0.44	7 - 18
17	26	13	3.9	0.76	6 - 20
18	13	13	3.7	1.02	7 - 21

et al., 1952). The range for the niacin value of the diets of Iowa children was 5 to 29 milligrams.

The mean daily niacin values for the diets of the Iowa boys were comparable to the values noted for the diets of the boys in the Northeast Region or in Groton Township (see Table 21).

The Iowa boys tended to have higher intakes of calories, vitamins A and C, thiamine, riboflavin and niacin than those of the Groton Township boys. The girls of Iowa seemed to have higher intakes of the various dietary components, except calcium, than the Groton Township girls.

The mean dietary differences noted between the Iowa children and the Groton Township children may be due somewhat to the fact that the means of the latter for each age group and sex were based on a one-day dietary record. In the Iowa study and in the Northeast-Region study the means were derived from seven-day records for each child. The estimate for the food energy and nutrient value based on one-day records may be misleading. Eppright *et al*. (1952) reported that the average number of servings obtained from records kept for fewer than seven days tended to be higher than the means from a seven-day record. A combination of any of the week days gave approximately the same estimates,

Table 21

Mean Daily Niacin Content of the Diets of Children of Iowa and of Other Places

Age group	7-9 years		10-12 years		13-15 years		16-18 years	
Places	No.	Mean mg.	No.	Mean mg.	No.	Mean mg.	No.	Mean mg.
Boys								
Iowa	163	12	201	14	116	16	69	17
New York[a] Groton Twp	34	12.1	29	14.1	25	17.4	19	17.7
New York[b]	43	10.2	43	13.7	104	17.6	9	17.2
Maine[b]	--	--	5	11.2	85	16.5	19	18.7
Rhode Island[b]	--	--	--	--	11	15.0	48	16.4
West Virginia[b]	--	--	--	--	--	--	101	17.4
Girls								
Iowa	153	11	204	13	120	13	75	12
New York[a] Groton Twp	23	9.7	10	10.7	20	10.8	24	10.9
New York[b]	44	9.2	53	11.5	113	13.6	8	12.4
Maine[b]	--	--	7	11.3	123	13.9	27	12.6
Rhode Island[b]	--	--	--	--	45	12.6	189	11.0
West Virginia[b]	--	--	--	--	--	--	131	12.2

[a]Young and Pilcher (1950).

[b]Tucker, et al. (1952).

but the week-end food intake differed significantly from the other five days.

Investigators often report dietary data in the age groups used in the tables of the Recommended Dietary Allowances of the National Research Council. It facilitates the comparison of the findings to the allowances. At each age within the period of school age, children may vary greatly from those in the preceding or following year, therefore, when two or three yearly ages are combined, the characteristics of each particular age may be lost. The characteristics of the age may be more evident if the children are considered in groups covering not more than twelve months.

Summary

1. For each age-sex group the mean, the standard deviation, the standard error of the mean and the range of the food energy and nutrient value of the diets of the Iowa children were calculated.

2. Except for the mean calcium content of the diets, the boys had mean intakes of food energy and other nutrients that either exceeded or approached the allowances.

3. With the exception of calcium and iron content, the diets of the Iowa girls had food energy values and

nutrient content, that approximated or exceeded the allowances from 6 through 12 years. After 13 years of age the girls had intakes of protein, thiamine and riboflavin in addition to calcium and iron that were below the allowances. For this age group of girls the values of the remaining nutrients fluctuated about the allowances.

4. The dietary intakes of calories and other nutrients of Iowa girls and boys were comparable to the intakes of the children in the Northeast Region and Louisiana where similar studies have been made. But the values for food energy and protein were markedly higher for the Iowa children than those for the Tennessee children.

BODY MEASUREMENTS OF IOWA CHILDREN IN RELATION TO NUTRIENT INTAKE AND TO BLOOD CONSTITUENTS

Growth is a characteristic of all living things. It is more evident in certain periods of life than in others. Weight and height are the measurements commonly used to assess growth.

> The height and weight are of different orders of growth and in a sense that they represent two growth functions; size or linearity; or volume or mass. They are, of course, correlated and integrated aspects of general bodily growth but only on a time linked basis. (Krogman, 1950, p. 56)

Growth in these two phases, height and weight, need not occur simultaneously.

Weights of Iowa Children

Weight is a measurement of mass or volume. The mass is made up of bone, muscle, blood, nerves, viscera, connective and adipose tissues; therefore, it becomes a complex measurement. For each age and sex the differences between the individual observations are greater for the measurement of weight than of height.

The factors that influence weight, other than the accuracy of instruments are: 1. the time of day; 2. recency of exercise, eating or elimination; 3. socio-economic status of the family of the child; 4. hereditary characteristics as racial stock and family tendencies in body build; and 5. seasonal factors (Krogman, 1950).

In making a series of consecutive measurements, the time of day is an important factor to consider. The diurnal fluctuation in weight of school children may be from two to three pounds. Sumner and Whitacre (1931) studied the differences in the weights of the same children taken in the morning and in the afternoon. These investigators observed that the apparent monthly weight gained was equal to the difference between the morning weight and afternoon weight.

A single weight measurement on one individual is of limited value, but one observation on a group of individuals provides a way for describing the physical status of the population under study. For example, the means, standard deviation, standard error of the mean and range of the weights of the children for a specified age-sex group will point out: 1. the distribution of the weights for each age and sex; 2. the variation present in the data. The statistics of this weight datum may be compared to similar data from other studies. The results of the weight measurements may be a basis for a standard, to which children in the same population from which the sample was drawn, may be compared.

Mean weights of total sample of Iowa children

A single weight measurement was made on 1194 Iowa children, 593 boys and 601 girls. In Table 22 the mean, standard deviation, standard error of the mean, and range of the weights of these children are presented for each age and sex.

The mean weight at each age was greater for the boys than for the girls, except at 10 and 11 years. The sex differences were most apparent from 14 to 17 years of age. To 13 years the boys exhibited less variability in weight than the girls. After 14 years the weights of the boys varied more than those of the girls. The range of weights of the boys varied from 13 kilograms at 6 years to 55 at 17 years. For the girls the range varied from 16 kilograms at 6 years to 51 at 12 years. The standard deviations were the largest at 14 and 17 years for the boys, and at 12 years for the girls.

Table 22

Mean Weight of Iowa Children

Age yr.	No.	Mean kg.	Standard deviation kg.	Standard error kg.	Range kg.
			Boys		
6	38	22.6	2.87	0.47	17.1 - 30.4
7	58	25.0	3.52	0.46	17.7 - 40.8
8	53	28.6	4.79	0.66	21.3 - 42.0
9	55	32.1	5.61	0.76	22.2 - 45.8
10	60	33.7	4.55	0.59	29.0 - 49.7
11	50	37.9	7.98	1.13	25.2 - 61.2
12	90	40.8	8.74	0.92	25.4 - 70.1
13	44	47.9	8.87	1.34	28.1 - 67.1
14	40	51.4	10.59	1.67	34.5 - 75.3
15	32	61.6	7.08	1.25	46.0 - 79.2
16	34	63.6	9.76	1.67	45.4 - 96.6
17	21	63.8	11.00	2.40	44.9 - 99.9
18	18	66.1	9.55	2.25	49.0 - 83.0
			Girls		
6	50	22.0	3.44	0.49	15.9 - 32.7
7	48	24.8	4.92	0.71	12.0 - 42.6
8	44	26.3	4.43	0.67	19.5 - 41.3
9	64	30.7	6.53	0.82	19.5 - 52.2
10	61	35.3	7.77	1.00	22.7 - 54.0
11	58	40.1	7.93	1.04	25.4 - 57.2
12	82	45.6	11.41	1.26	28.1 - 79.8
13	44	46.8	8.78	1.32	27.9 - 64.2
14	37	51.3	7.24	1.19	37.2 - 67.6
15	38	56.6	8.04	1.30	40.8 - 71.2
16	37	57.2	8.93	1.47	44.0 - 86.6
17	26	57.5	9.22	1.81	43.3 - 81.6
18	12	54.1	4.38	1.26	45.4 - 60.6

The greatest increment in the weight of the boys as shown by means at successive years was between the ages of 14 and 15 years. The girls had no conspicuously large increment.

Comparison of weights of Iowa children with those of other studies

It is difficult to compare the weights of the Iowa children with other studies because many investigators report their findings as per cent deviation from a standard. Jackson and Kelly (1945) reported the median of the weight data for each age and sex of Iowa children measured from 1920 to 1940. These investigators believed that the median was a better measure of central tendency since the frequency distribution of the weight measurements for each age and sex is skewed toward the heavier weights. The skewness of data can be denoted when the mean and the standard deviation and range accompany the data.

The mean weight for each age-sex group of the Iowa children in this study was compared with the mean weights of children observed in two other studies in Iowa, and in studies conducted in Denver and Chicago (see Table 23).

Table 23

Comparison of Mean Weights of Iowa School Children with Similar Data f

Boys

Age in yrs.	Iowa (1953)[a] No.	Mean	s.d.	Iowa (1941)[b] No.	Mean	s.d.	Iowa (1945)[c] No.	50th Percentile	Chicag No.	M
		kg	kg		kg	kg		kg		
6	38	22.6	2.87	417	21.4	2.80	-	20.8	114	2
7	58	25.0	3.52	429	23.6	3.00	-	23.2	143	2
8	53	28.6	4.79	344	26.6	4.11	-	26.0	147	2
9	55	32.1	5.61	483	29.4	4.34	-	28.2	167	3
10	60	33.7	4.55	554	33.0	5.26	-	31.5	173	3
11	50	37.9	7.98	501	35.6	6.25	-	34.4	201	3
12	90	40.8	8.74	321	38.1	7.04	-	37.0	247	4
13	44	47.9	8.87	229	43.4	8.23	-	42.3	293	4
14	40	51.4	10.59	168	48.7	9.53	-	47.3	373	4
15	32	61.6	7.08	-	-	-	-	54.5	362	5
16	34	63.6	9.76	-	-	-	-	58.2	292	6
17	21	63.8	11.00	-	-	-	-	62.5	229	6
18	18	66.1	9.55	-	-	-	-	-	129	6

[a]Present study

[b]U.S.D.A. Miscellaneous Publication No. 366

[c]Jackson and Kelly (1945)

[d]Gray and Ayres (1931)

[e]Maresh (1948)

Table 23

Weights of Iowa School Children with Similar Data from Selected Studies

Boys

owa (1941)[b]		Iowa (1945)[c]		Chicago (1931)[d]			Denver (1948)[e]		
Mean	s.d.	No.	50th Percentile	No.	Mean	s.d.	No.	Mean	s.d.
kg	kg		kg		kg	kg		kg	kg
21.4	2.80	-	20.8	114	22.2	3.01	175	22.2	2.05
23.6	3.00	-	23.2	143	24.6	3.25	164	25.2	2.46
26.6	4.11	-	26.0	147	27.9	3.98	169	28.1	3.09
29.4	4.34	-	28.2	167	30.9	4.78	164	30.8	3.75
33.0	5.26	-	31.5	173	34.4	5.17	151	33.5	4.10
35.6	6.25	-	34.4	201	37.6	5.82	142	36.2	4.75
38.1	7.04	-	37.0	247	40.7	6.59	135	40.0	5.74
43.4	8.23	-	42.3	293	44.8	7.57	123	45.1	7.16
48.7	9.53	-	47.3	373	49.4	8.06	97	50.8	7.37
-	-	-	54.5	362	56.0	9.25	71	55.6	7.01
-	-	-	58.2	292	60.6	8.87	48	60.3	6.99
-	-	-	62.5	229	64.3	8.42	39	62.4	7.47
-	-	-	-	129	66.1	9.78	58	66.5	7.04

on No. 366

The boys included in the random sample obtained from 61 places in Iowa were heavier than the boys observed by Jackson and Kelly (1945) at the Iowa Child Welfare Research Station at the University of the State of Iowa, Iowa City.

The boys, 6 to 14 years, weighed more at each age than the Iowa boys in the study conducted by the Bureau of Human Nutrition and Home Economics from 1937 to 1939 on the children throughout the nation (Misc. Pub. No. 336, 1941). From 6 to 12 years the mean weights of Iowa boys compared favorably to the mean weight of the Denver boys (Maresh, 1948) and the Chicago boys (Gray and Ayres, 1931). From 13 to 18 years the weights fluctuated about the mean of the Denver and the Chicago boys. This sample of Iowa boys, representative of a large population, was heavier than the Iowa boys that came primarily from the vicinity of Iowa City.

From 6 to 12 years the weights of the Iowa girls were most like those observed by Gray and Ayres (1931) in Chicago and Maresh (1948) in Denver (see Table 24). From 12 to 18 years the Iowa girls tended to exceed the mean weights reported in other studies.

Table 24

Comparison of Mean Weights of Iowa School Children with Similar Data

Girls

Age in yrs.	Iowa (1953)[a] No.	Mean	s.d.	Iowa (1941)[b] No.	Mean	s.d.	Iowa (1945)[c] No.	50th Percentile	Ohio No.
		kg	kg		kg	kg		kg	
6	50	22.0	3.44	445	20.9	2.63	-	20.3	74
7	48	24.8	4.92	535	23.5	3.25	-	22.5	90
8	44	26.3	4.43	492	26.3	4.53	-	25.2	100
9	64	30.7	6.53	539	29.0	4.89	-	28.0	122
10	61	35.3	7.77	542	32.2	5.87	-	31.1	110
11	58	40.1	7.93	540	35.9	6.24	-	34.4	139
12	82	45.6	11.41	323	40.7	7.23	-	39.6	126
13	44	46.8	8.78	181	44.2	8.36	-	44.5	124
14	37	51.3	7.24	134	48.2	8.07	-	49.0	108
15	38	56.6	8.04	-	-	-	-	51.5	96
16	37	57.2	8.93	-	-	-	-	52.7	86
17	26	57.5	9.22	-	-	-	-	53.5	86
18	12	54.1	4.38	-	-	-	-	-	51

[a]Present study

[b]U.S.D.A. Miscellaneous Publication No. 366

[c]Jackson and Kelly (1945)

[d]Gray and Ayres (1931)

[e]Maresh (1948)

Table 24

ights of Iowa School Children with Similar Data from Selected Studies

Girls

(1941)[b]		Iowa (1945)[c]		Chicago (1931)[d]			Denver (1948)[e]		
Mean	s.d.	No.	50th Percentile	No.	Mean	s.d.	No.	Mean	s.d.
kg	kg		kg		kg	kg		kg	kg
20.9	2.63	-	20.3	74	22.4	2.96	145	21.8	2.77
23.5	3.25	-	22.5	90	25.1	2.86	146	24.8	3.67
26.3	4.53	-	25.2	100	27.9	4.83	136	27.9	4.48
29.0	4.89	-	28.0	122	31.8	4.82	118	31.8	5.69
32.2	5.87	-	31.1	110	35.2	6.40	104	35.6	6.64
35.9	6.24	-	34.4	139	39.1	7.24	100	39.6	8.23
40.7	7.23	-	39.6	126	43.7	8.23	93	44.0	9.16
44.2	8.36	-	44.5	124	47.9	8.29	92	48.5	8.94
48.2	8.07	-	49.0	108	50.7	7.98	73	52.0	8.71
-	-	-	51.5	96	54.5	7.72	43	53.4	8.89
-	-	-	52.7	86	55.7	7.63	34	54.7	8.70
-	-	-	53.5	86	57.0	7.10	21	54.8	7.37
-	-	-	-	51	57.4	5.81	28	55.3	5.33

No. 366

Study of the heaviest, lightest and medium weight children

To study the dietary habits and blood constituents of heaviest and lightest weight boys and girls, each age and sex group was divided into three groups. Group I consisted of individuals whose weights were within minus second or third standard deviations from the mean of the age-sex group; Group II those whose weights were within the plus second or third standard deviations from the mean; Group III those whose weights were within the plus or minus one standard deviation.

Physical status. It may be noted in Figures 2 and 3 that the mean weights of boys and girls in Group I were below the 16th percentile except for the 15 year old boys. This group as a whole may be considered as the lightest weight boys and girls. The mean weights of the children in Group II were above the 84th percentile. They may be considered as the heaviest weight boys and girls. The mean weights of the children of Group III were in the area between the 16th and 84th percentiles, close to the median. This group was of medium weight.

Figure 2. Mean heights and weights of Iowa boys classified according to weight groups.

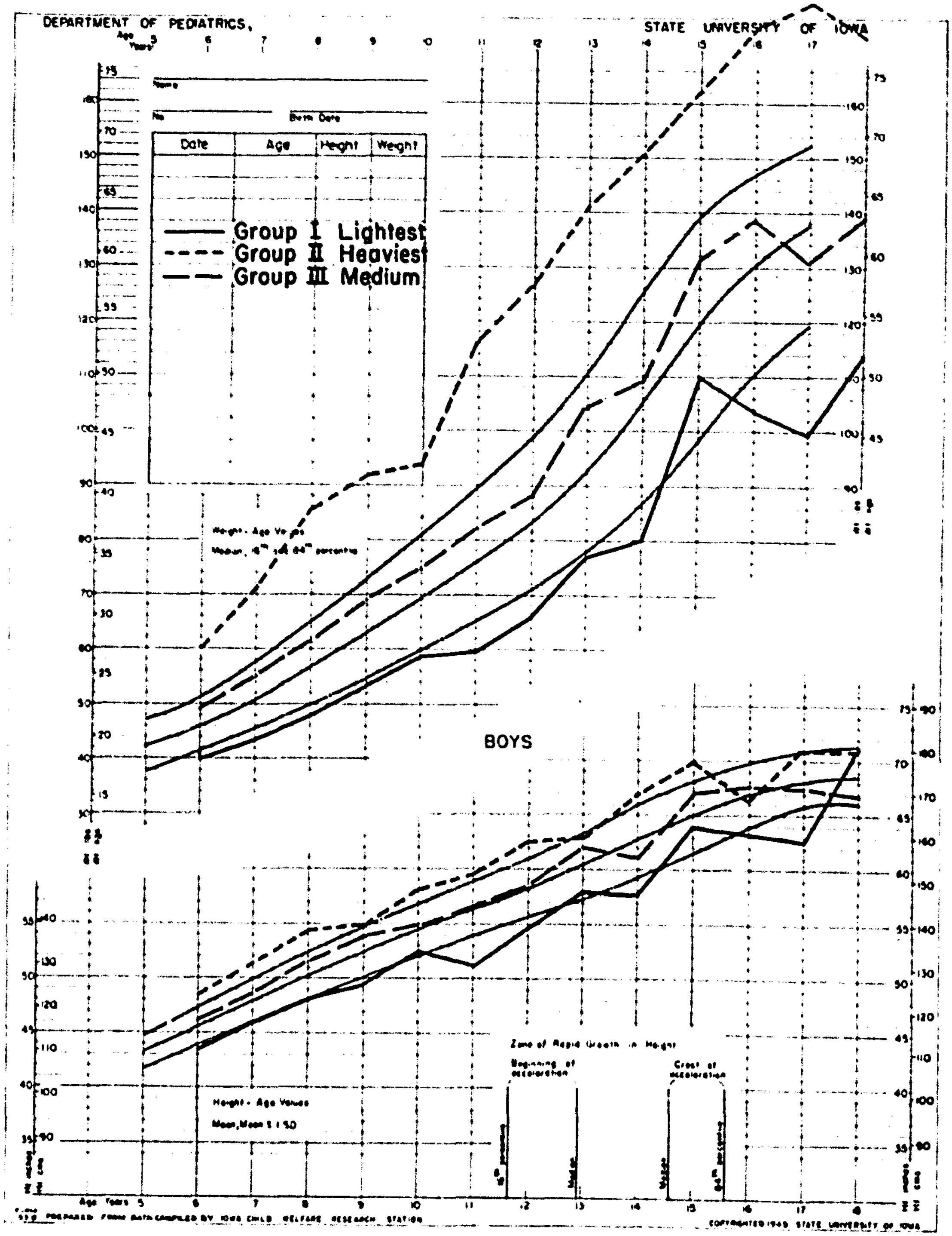
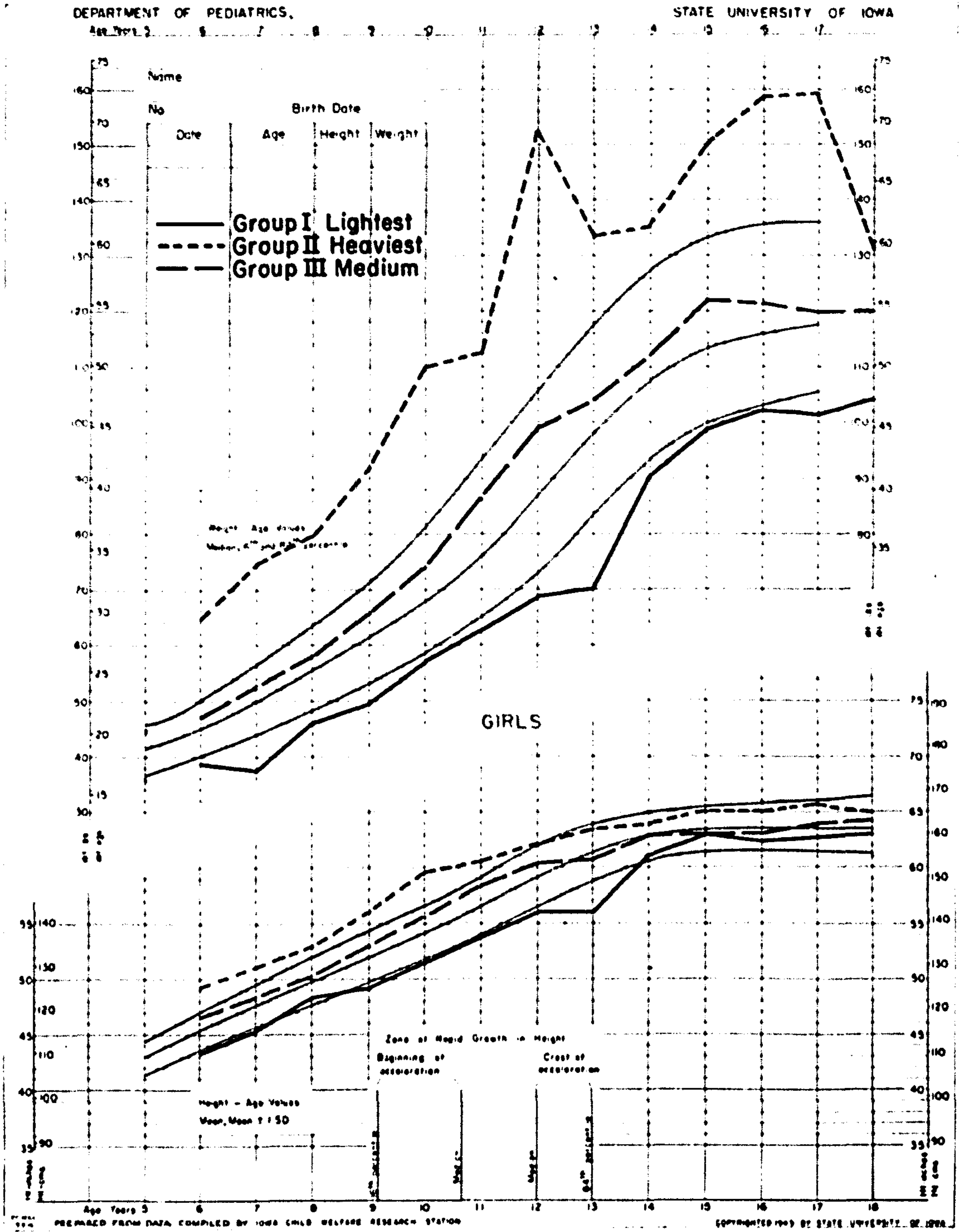

DEPARTMENT OF PEDIATRICS,
STATE UNIVERSITY OF IOWA
Date
Age
Height
Weight
Group I Lightest
Group II Heaviest
Group III Medium
BOYS
Height - Age Values
Mean, Mean ± 1 SD
Zone of Rapid Growth in Height
Beginning of acceleration
Crest of acceleration
Age Years

Figure 3. Mean weights of Iowa girls classified according to weight groups.


DEPARTMENT OF PEDIATRICS,
STATE UNIVERSITY OF IOWA
Name
No
Birth Date
Date
Age
Height
Weight
Group I Lightest
Group II Heaviest
Group III Medium
GIRLS
Age Years

In the discussion these groups will be referred to as lightest weight, heaviest weight and medium weight. Of the total number of boys and girls, 11 per cent of the boys and 13 per cent of the girls were in the group with lightest weight, 12 per cent of the boys and 16 per cent of the girls were in the group with heaviest weight, and 77 per cent of the boys and 71 per cent of the girls were in the medium group.

The children of heaviest weight were taller than those of lightest weight. The children of medium weight had mean heights that were between the heights of the children of heaviest weight and of lightest weight, except for the heaviest weight 16-year-old boys (Table 25).

Nutrient intake. The mean daily food energy and nutrient value of the diets of the children classified according to weight for each age-sex group are presented in Tables 26 and 27.

The boys of heaviest weight had mean food energy values that were nearly always above the values for the boys of lightest weight at corresponding ages (see Figure 4). Except at 9, 16, 17 and 18 years the boys of medium weight had diets with food energy values that tended to be intermediate to those of the boys of heaviest weight and the lightest weight.

Table 25

Mean Heights of Iowa Children Classified According to Weight Groups

Groups[a]	I		II		III	
Age yr.	No.	Cm.	No.	Cm.	No.	Cm.
			Boys			
6	5	111	4	124	28	118
7	5	117	5	131	46	124
8	2	123	5	138	46	131
9	8	126	7	139	38	137
10	7	133	6	147	47	139
11	3	131	7	151	40	144
12	12	139	12	158	66	148
13	6	147	6	160	32	158
14	5	147	7	172	27	155
15	4	162	5	179	23	171
16	3	161	3	169	25	172
17	1	159	2	180	18	172
18	2	180	4	180	11	169
			Girls			
6	6	110	5	124	39	118
7	3	115	6	129	39	122
8	7	122	5	133	31	126
9	9	124	11	142	42	133
10	6	130	11	150	44	140
11	10	136	12	152	36	147
12	13	143	9	157	59	152
13	6	143	6	160	32	153
14	5	154	8	162	24	160
15	5	160	9	165	24	160
16	4	158	6	165	26	160
17	2	159	5	167	18	162
18	2	160	2	165	8	163

[a]Group I--Weights minus 2 or 3 standard deviations
Group II--Weights plus 2 or 3 standard deviations
Group III--Weights within ± 1 standard deviations

Table 26

Mean Daily Food Energy Value and Nutrient Content of Diets of Iowa Children Classified According to Three Weight Groups

Boys

Age in yrs.	No.	Group[a]	Weight kg.	Age in mos.	Food Energy cal.	Protein gm.	Calcium mg.	Iron mg.	Ascorbic acid mg.
6	5	I	18.4	76	1923	63	966	9	80
	4	II	27.5	79	2430	72	1048	11	92
	28	III	22.7	78	2218	67	1080	9	79
7	5	I	19.8	87	2107	60	814	9	61
	5	II	32.9	91	2369	76	1095	11	83
	46	III	24.9	89	2202	66	1044	10	74
8	2	I	22.0	100	1750	58	1060	7	78
	5	II	39.2	99	2282	72	1029	11	114
	46	III	27.8	99	2269	72	1136	10	74
9	8	I	24.6	111	2331	70	1098	11	77
	7	II	41.9	116	2419	76	1071	11	90
	38	III	31.9	114	2518	76	1135	12	86
10	7	I	27.6	124	2547	78	980	12	80
	6	II	42.6	128	2381	73	933	12	87
	47	III	33.5	125	2402	73	1064	11	75
11	3	I	26.6	136	2630	74	1200	11	69
	7	II	53.7	138	2869	95	1387	13	98
	40	III	36.0	137	2569	77	1094	11	84

[a]Group

I Weights - Minus 2 or 3 standard deviations

II Weights - Plus 2 or 3 standard deviations

III Weights - Within 1 standard deviation

Table 26

an Daily Food Energy Value and Nutrient Content of Diets
Iowa Children Classified According to Three Weight Groups

Boys

Age in mos.	Food Energy cal.	Protein gm.	Calcium mg.	Iron mg.	Ascorbic acid mg.	Thiamine mg.	Ribo-flavin mg.	Niacin mg.
76	1923	63	966	9	80	0.9	1.7	10
79	2430	72	1048	11	92	1.2	1.8	13
78	2218	67	1080	9	79	1.1	1.9	11
87	2107	60	814	9	61	1.0	1.6	12
91	2369	76	1095	11	83	1.2	2.2	12
89	2202	66	1044	10	74	1.0	1.9	11
100	1750	58	1060	7	78	0.9	1.8	8
99	2282	72	1029	11	114	1.2	1.9	12
99	2269	72	1136	10	74	1.1	2.1	12
111	2331	70	1098	11	77	1.1	2.1	12
116	2419	76	1071	11	90	1.2	2.0	13
114	2518	76	1135	12	86	1.2	2.1	13
124	2547	78	980	12	80	1.2	1.8	15
128	2381	73	933	12	87	1.1	2.0	14
125	2402	73	1064	11	75	1.1	2.0	13
136	2630	74	1200	11	69	1.1	2.1	11
138	2869	95	1387	13	98	1.4	2.4	16
137	2569	77	1094	11	84	1.2	2.1	13

standard deviations

standard deviations

standard deviation

Table 26 (continued)

Age in yrs.	No.	Group[a]	Weight kg.	Age in mos.	Food energy cal.	Protein gm.	Calcium mg.	Iron mg.	Ascorbi[c] acid mg.
12	12	I	30.1	149	2488	77	850	13	63
	12	II	57.8	149	3096	97	1280	15	109
	66	III	39.6	148	2722	84	1157	13	84
13	6	I	36.4	159	2484	75	908	12	77
	6	II	64.0	162	3024	93	1207	14	75
	32	III	47.0	161	2922	88	1157	14	105
14	5	I	36.6	172	3024	88	960	14	68
	7	II	68.5	173	3152	96	1056	15	60
	27	III	48.4	174	3083	90	1156	14	103
15	4	I	51.3	183	3282	97	1103	16	105
	5	II	73.3	186	3423	100	1166	17	103
	23	III	60.9	185	3209	91	1192	15	95
16	3	I	47.1	197	3042	85	1160	13	89
	3	II	85.2	198	3226	98	1358	14	103
	25	III	63.1	196	3490	101	1327	16	114
17	1	I	44.9	209	1843	76	1221	9	57
	2	II	88.0	211	2898	90	1046	13	62
	18	III	59.3	210	3541	108	1497	17	108
18	2	I	52.0	228	3236	98	1260	15	60
	4	II	80.4	224	3513	101	1410	15	110
	11	III	63.6	221	3449	104	1084	16	81

Age in mos.	Food energy cal.	Protein gm.	Calcium mg.	Iron mg.	Ascorbic acid mg.	Thiamine mg.	Ribo-flavin mg.	Niacin mg.
149	2488	77	850	13	63	1.2	1.8	14
149	3096	97	1280	15	109	1.4	2.5	16
148	2722	84	1157	13	84	1.3	2.2	15
159	2484	75	908	12	77	1.1	1.8	13
162	3024	93	1207	14	75	1.4	2.3	15
161	2922	88	1157	14	105	1.4	2.2	16
172	3024	88	960	14	68	1.4	1.9	17
173	3152	96	1056	15	60	1.5	2.3	17
174	3083	90	1156	14	103	1.5	2.2	16
183	3282	97	1103	16	105	1.5	2.3	20
186	3423	100	1166	17	103	1.6	2.7	19
185	3209	91	1192	15	95	1.5	2.5	16
197	3042	85	1160	13	89	1.5	2.1	13
198	3226	98	1358	14	103	1.4	2.5	17
196	3490	101	1327	16	114	1.6	2.5	17
209	1843	76	1221	9	57	0.9	2.0	10
211	2898	90	1046	13	62	1.3	2.0	14
210	3541	108	1497	17	108	1.7	2.8	18
228	3236	98	1260	15	60	1.4	3.1	21
224	3513	101	1410	15	110	1.8	2.9	18
221	3449	104	1084	16	81	1.7	2.3	18

Table 27

Mean Daily Food Energy Value and Nutrient Content of Di
of Iowa Children Classified According to Three Weight G

Girls

Age in yrs.	No.	Group[a]	Weight kg.	Age in mos.	Food energy cal.	Protein gm.	Calcium mg.	Iron mg.	Ascor aci m
6	6	I	17.2	78	1663	52	754	8	6[illegible]
	5	II	29.2	77	1976	66	1141	9	8[illegible]
	39	III	21.8	78	2005	61	914	9	6[illegible]
7	3	I	16.6	89	1942	52	807	8	8[illegible]
	6	II	34.6	91	1972	67	1021	10	9[illegible]
	39	III	23.9	89	1993	61	861	9	7[illegible]
8	7	I	20.9	101	1744	53	808	8	6[illegible]
	5	II	35.6	102	2138	68	1277	10	9[illegible]
	31	III	26.1	100	2070	64	1011	9	7[illegible]
9	9	I	22.5	113	2433	73	957	11	8[illegible]
	11	II	42.1	114	2299	72	953	11	8[illegible]
	42	III	29.5	114	2245	68	957	10	8[illegible]
10	6	I	25.6	123	2166	63	885	10	8[illegible]
	11	II	49.0	128	2370	72	1009	12	10[illegible]
	44	III	33.2	125	2273	68	926	11	8[illegible]
11	10	I	28.1	136	2046	64	832	10	8[illegible]
	12	II	50.7	138	2271	70	1013	10	7[illegible]
	36	III	39.8	137	2318	70	967	10	8[illegible]

[a]Group

I Weights - Minus 2 or 3 standard deviations

II Weights - Plus 2 or 3 standard deviations

III Weights - Within 1 standard deviation

Table 27

Daily Food Energy Value and Nutrient Content of Diets
owa Children Classified According to Three Weight Groups

Girls

Age in mos.	Food energy cal.	Protein gm.	Calcium mg.	Iron mg.	Ascorbic acid mg.	Thiamine mg.	Ribo-flavin mg.	Niacin mg.
78	1663	52	754	8	68	0.8	1.4	9
77	1976	66	1141	9	83	1.0	2.1	10
78	2005	61	914	9	64	1.0	1.7	10
89	1942	52	807	8	89	0.9	1.7	10
91	1972	67	1021	10	91	1.1	1.8	10
89	1993	61	861	9	74	1.0	1.6	10
101	1744	53	808	8	67	0.9	1.5	9
102	2138	68	1277	10	90	1.0	2.2	11
100	2070	64	1011	9	75	1.0	1.8	10
113	2433	73	957	11	81	1.1	1.9	13
114	2299	72	953	11	83	1.1	1.9	12
114	2245	68	957	10	82	1.1	1.8	12
123	2166	63	885	10	85	1.1	1.7	12
128	2370	72	1009	12	100	1.2	2.0	13
125	2273	68	926	11	82	1.1	1.8	12
136	2046	64	832	10	83	1.0	1.7	11
138	2271	70	1013	10	72	1.1	1.9	12
137	2318	70	967	10	82	1.1	1.9	12

andard deviations

ndard deviations

ndard deviation

Table 27 (continued)

Age in yrs.	No.	Group[a]	Weight kg.	Age in mos.	Food energy cal.	Protein gm.	Calcium mg.	Iron mg.	Ascorb acid mg.
12	13	I	31.5	148	2709	82	1089	13	67
	9	II	69.6	149	2259	72	1038	11	95
	59	III	45.1	149	2663	82	1106	12	85
13	6	I	31.5	158	2268	71	918	11	70
	6	II	60.5	161	2772	84	1287	12	78
	32	III	47.2	161	2453	72	954	12	76
14	5	I	41.6	172	2425	72	1102	12	65
	8	II	61.4	172	2428	71	933	12	89
	24	III	50.0	173	2519	76	982	11	83
15	5	I	44.6	183	2698	84	1040	13	104
	9	II	68.0	186	2588	72	787	12	98
	24	III	56.3	186	2682	74	911	12	86
16	4	I	46.3	192	2832	75	892	13	140
	6	II	73.0	197	2118	70	790	10	77
	26	III	55.3	198	2277	68	804	11	86
17	2	I	45.5	208	2523	75	811	12	77
	5	II	73.3	209	2068	63	795	10	82
	18	III	54.6	209	2439	75	812	12	90
18	2	I	46.6	222	2551	84	1067	11	75
	2	II	59.6	222	2060	56	588	10	82
	8	III	54.6	222	2471	74	801	12	98

Age in mos.	Food energy cal.	Protein gm.	Calcium mg.	Iron mg.	Ascorbic acid mg.	Thiamine mg.	Ribo-flavin mg.	Niacin mg.
148	2709	82	1089	13	67	1.2	2.1	14
149	2259	72	1038	11	95	1.1	2.0	13
149	2663	82	1106	12	85	1.3	2.1	14
158	2268	71	918	11	70	1.1	1.7	12
161	2772	84	1287	12	78	1.2	2.4	14
161	2453	72	954	12	76	1.1	1.8	13
172	2425	72	1102	12	65	1.1	1.8	12
172	2428	71	933	12	89	1.1	1.9	13
173	2519	76	982	11	83	1.3	2.0	13
183	2698	84	1040	13	104	1.3	2.0	15
186	2588	72	787	12	98	1.1	1.7	14
186	2682	74	911	12	86	1.2	1.8	14
192	2832	75	892	13	140	1.4	2.0	13
197	2118	70	790	10	77	1.1	1.6	12
198	2277	68	804	11	86	1.1	1.6	12
208	2523	75	811	12	77	1.3	2.3	14
209	2068	63	795	10	82	1.0	1.4	10
209	2439	75	812	12	90	1.2	1.7	13
222	2551	84	1067	11	75	1.3	2.0	14
222	2060	56	588	10	82	1.0	1.2	11
222	2471	74	801	12	98	1.2	1.6	14

The diets of the boys of heaviest weight had mean energy values above the allowances from 6 to 15 years. The diets of the boys of lightest weight had mean energy values that were below the recommendations except at 9, 10, 11 and 15 years. The mean daily food energy value of the diets of the boys of medium weight conformed closely to the allowances. The values were slightly higher than the allowances to 12 years, but a little below from 12 to 18 years.

The diets of the girls of heaviest weight had mean food energy values that exceeded those of the girls of lightest weight to 13 years of age except at 9 and 12. After 13 years the diets of the girls of lightest weight had mean energy values that were greater than those of the girls of heaviest weight. This difference may reflect an effort on the part of the girls of heaviest weight to restrict their caloric intake. The mean food energy value of the diets of the girls of average weight was not consistently intermediate to the calorie values of the diets of the girls of heaviest weight and of lightest weight.

The mean daily food energy value of the diets of the girls of medium weight approximated the allowances within 100 to 150 calories. The greatest deviation from the allowances occurred at 6, 7 and 16 years.

The girls of heaviest weight and of lightest weight had mean energy food values that fluctuated irregularly about the allowances, but the mean daily food energy values of the diets of the girls of heaviest weight (15 to 18 years) were about 300 calories lower than the allowances. The relationship of food energy intake to weight status was more consistent for boys than for girls.

The mean protein content of the diets of the boys of heaviest weight was greater than that of the diets of the boys of lightest weight except for the 10-year-olds. At this age the mean daily protein intake was about the same regardless of weight (see Figure 5).

Except at 15 to 17 years of age the diets of the boys of medium weight had mean daily protein values which were between the corresponding values for the groups of the heaviest weight and of the lightest weight. The mean protein content of the diets of the boys of medium weight always exceeded the allowances by 5 to 10 grams. The boys of heaviest weight had dietary protein values that were greater than the recommendations at all ages except at 15 years. In the group of lightest weight, at five ages the mean daily intake of protein did not meet the allowances. The boys of lightest weight tended to have diets poor in protein both as related to diets of boys of medium weight and as related to the allowances.

The mean protein content of the diets of the girls of heaviest weight indicated a greater protein consumption by them

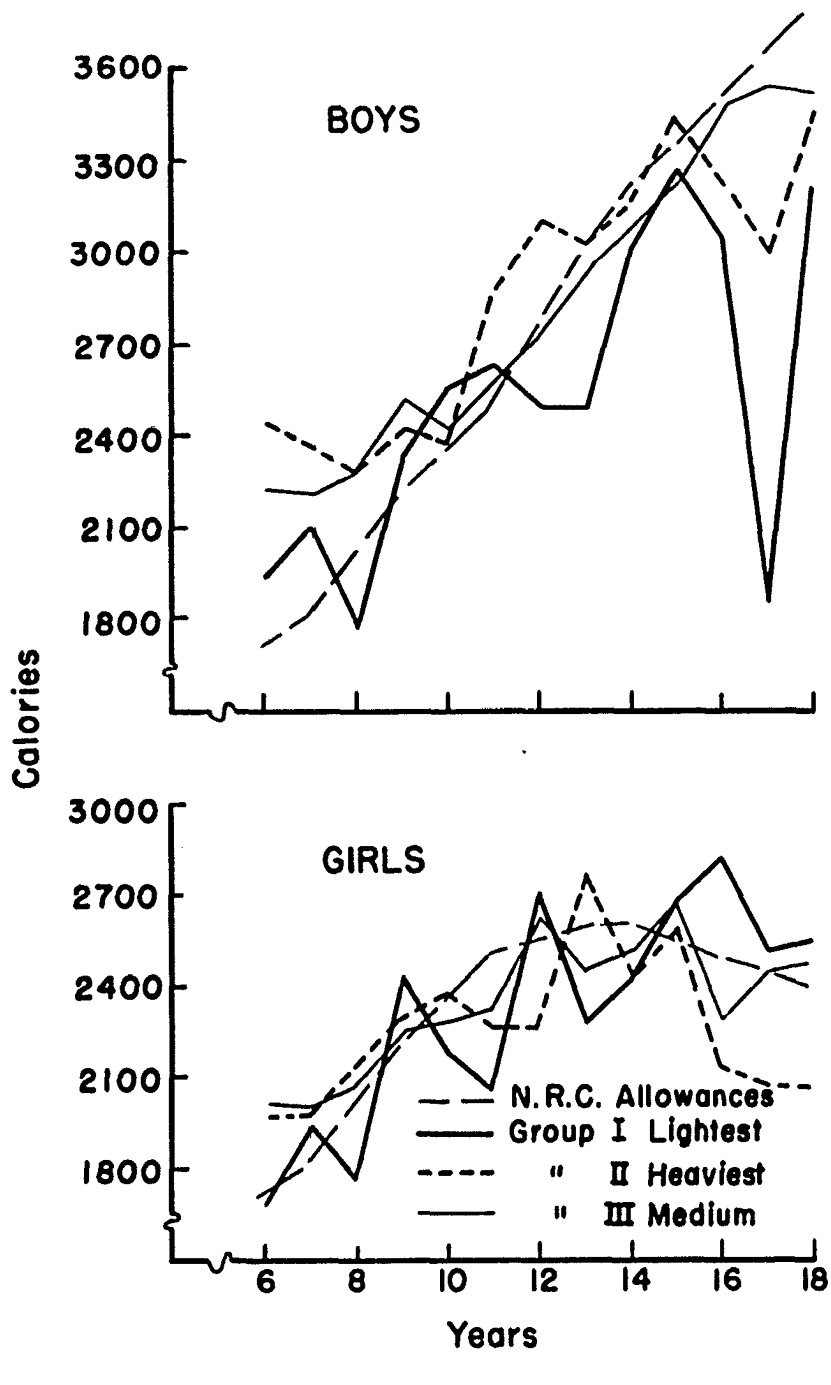


Fig. 4 Mean daily food energy value of the diets of Iowa children classified according to three weight groups.

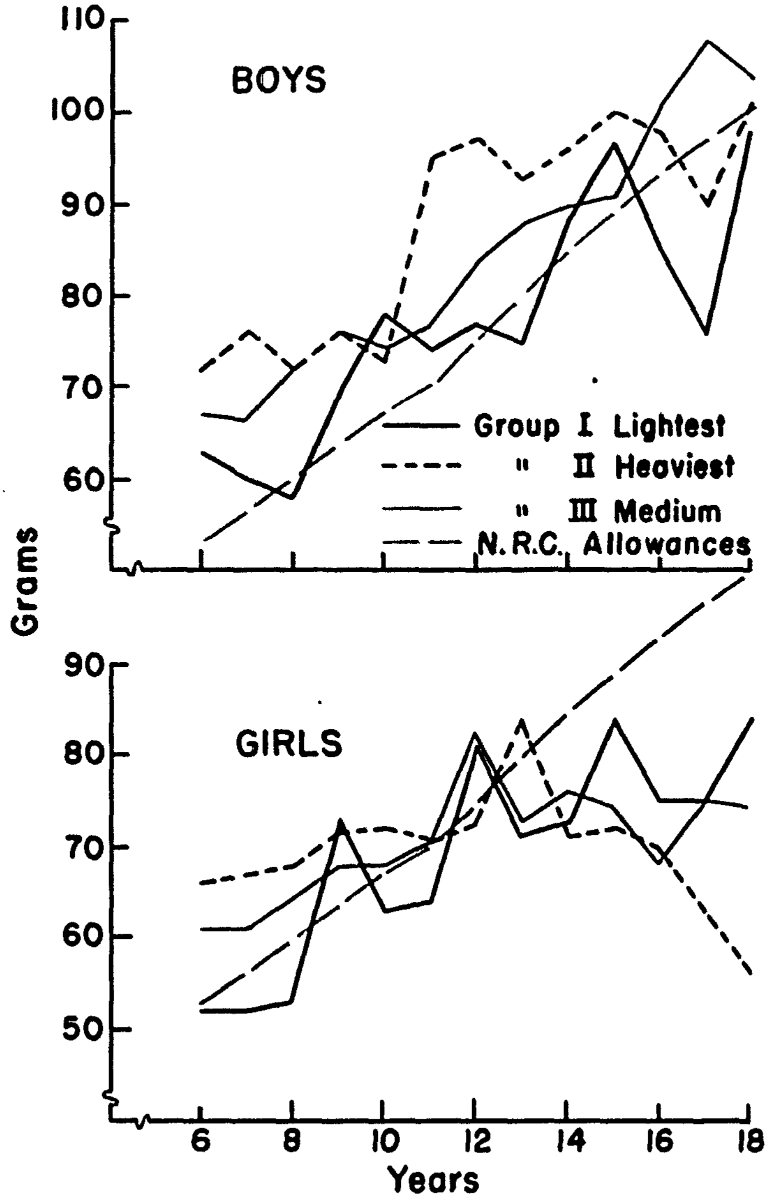


Fig. 5 Mean daily protein content of the diets of Iowa children classified according to three weight groups.

than by the girls of lightest weight from the ages of 6 to 13 years, except at 9 and 12 years of age. After this age the protein intake of girls of heaviest weight decreased sharply and was poorer than that of the girls who were either of medium or lightest weight. For girls younger than 11 years, the mean protein intake tended to vary directly with the weight classification, but afterwards there was no consistent relationship between weight and protein values. From 6 to 13 years the girls of medium weight had diets with mean protein values that approximated the allowances. The greatest deviation below the allowances occurred at 16 years. From 6 to 12 years the diets of the girls of heaviest weight had mean protein values that exceeded or met the allowances. From 13 to 18 years the mean protein content of the diets of the girls of heaviest weight declined steadily to values 20 grams below the recommended allowances. For 9 out of 13 age groups the girls of lightest weight had protein intakes below the allowances.

At most ages the mean calcium content of the diets of the boys with the lightest weight was less than that of the diets of the boys of the heaviest weight or of medium weight (see Figure 6).

The boys of medium weight had diets with calcium content greater than the allowances only at 6 to 9 years

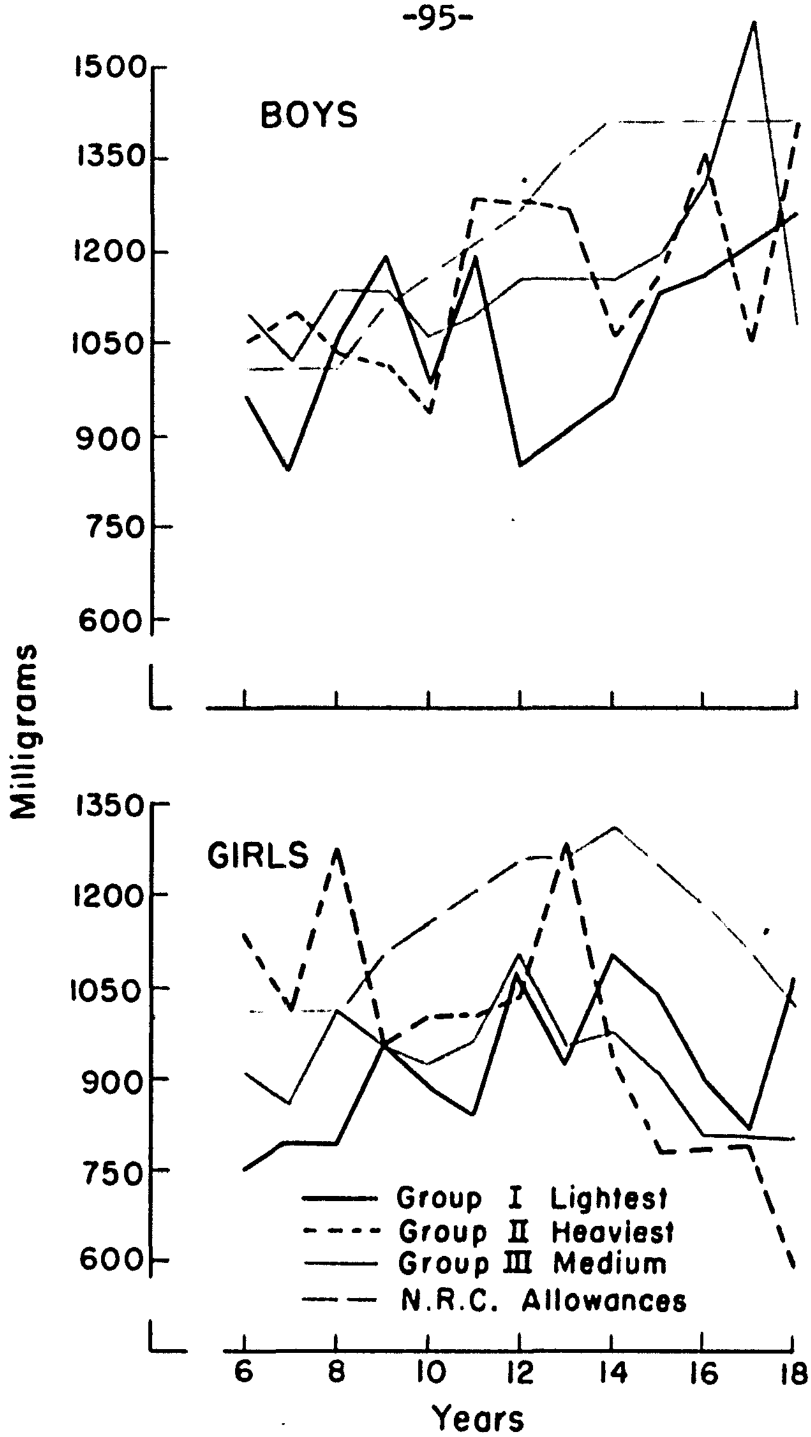


Fig. 6 Mean calcium content of diets of Iowa children classified according to three groups of weights

and at 17 years, whereas at the other ages the calcium intakes were below the allowances. The lightest weight boys had calcium values below the allowances at all ages except 9 years. For the heaviest weight boys the mean daily calcium content approached the allowances except for the 10, 14, 15 and 17 year olds.

To 13 years the mean calcium content of the diet of the heaviest weight girls was greater than that of the lightest weight girls. After 13 years the heaviest weight girls had diets with calcium values below those of the lightest weight girls. Below 12 years the girls of medium weight had calcium intakes that tended to be intermediate between the values of the other two extreme weight groups. Regardless of weight classification, the girls seldom had mean daily calcium intakes equal to the allowances. Heaviest weight girls to 13 years tended, more often than the others, to have calcium intakes equal to the allowances, but after 13 years the calcium intakes of this group diverged most from the allowances.

At most ages the mean daily ascorbic acid content of the diets of the heaviest weight boys was greater than corresponding data for the lightest weight boys, but the medium weight group was not intermediate with reference to the usage of this vitamin.

The heaviest weight boys had diets with ascorbic acid levels that surpassed the recommendations, except at 13, 14 and 17 years. The mean daily ascorbic acid content of the diets of the lightest weight boys was equal to or greater than the allowances to 10 years, but afterwards was below the recommendations except at 15 years. The boys with medium weight had diets with mean daily ascorbic acid values which exceeded the allowances at most ages.

The heaviest weight girls had diets with mean ascorbic acid content that was greater than that observed for the lightest weight girls at most ages (see Table 26). The heaviest weight girls and the girls with medium weight had diets with mean ascorbic acid contents that either exceeded or approximately met the allowances throughout the age range. Of the three groups the lightest weight girls were the only ones that tended to have diets with less than the allowances in ascorbic acid. Ascorbic acid was the only nutrient for which the diets of the heaviest weight girls of the late teens were superior to those of the lightest weight girls.

As shown by the means the heaviest weight boys usually consumed diets richer in thiamine than were those consumed by the lightest boys. The boys of medium weight had diets with mean values that tended to be intermediate between the values of the other two groups.

The thiamine value of the diets of boys of medium weight conformed closely to the allowances at most ages. The consumption of thiamine by the lightest weight boys was generally lower than the recommendations. To 15 years the mean thiamine value of the diets of the lightest weight boys either exceeded or were equal to the allowances.

With the exception of the 9-and 12-year-olds the heaviest weight girls to 14 years tended to have diets containing more thiamine than the diets of the lightest weight girls, but after 14 years the heaviest weight girls had lower consumption of thiamine than had the lightest weight girls.

The mean thiamine value of the diets of the three weight groups tended to fluctuate somewhat below the allowances. After 15 years age the lightest weight girls had diets which exceeded the allowances in thiamine whereas the heaviest weight girls had diets considerably lower than the allowances.

The mean daily riboflavin intake of the heaviest weight and medium weight boys at most ages was greater than the intake for the lightest weight boys. The boys of medium weight consumed diets that contained amounts of riboflavin slightly less than the amounts eaten by the boys of heaviest weight. The weight status of the boys roughly paralleled the riboflavin as well as the protein intakes. The riboflavin consumption of boys of medium weight and of the heaviest weight exceeded the allowances at nearly all ages. The boys of lightest weight had diets in which the riboflavin intakes were often below the allowances.

From 6 to 13 years the mean riboflavin value of the diets of the girls of the heaviest weight nearly always surpassed the corresponding figures for the girls of lightest weight. From 13 to 18 years the values for the two groups reversed their positions. At a number of ages the mean daily riboflavin intake of girls of medium weight maintained an intermediate position between the corresponding figures for the groups of the heaviest weight and of the lightest weight.

The girls of medium weight had diets with mean riboflavin content that exceeded the allowances to 12 years, but afterwards were considerably below the recommendations. The mean riboflavin content of the diets of the girls of heaviest weight followed the same trend, only with a precipitous drop after 13 years. The riboflavin content of the diets reached a value 0.6 mg. below the allowances at 18 years, or only two-thirds of the allowances. The girls of lightest weight had intakes with riboflavin content which exceeded the allowances in the earlier and later school years, but tended to be less than the allowances from 10 to 15 years.

In general, the heaviest weight boys had mean daily niacin intakes that were above the lightest weight boys, except at the ages of 10, 15 and 18 years. The boys of average weight tended to have mean daily niacin intakes between the values of the two groups (see Table 25).

Except for the 15-year-olds, the boys of medium weight had niacin intakes that were about two milligrams higher than the amount indicated by the allowances. The mean niacin value for the lightest weight boys fluctuated about the allowances, while the heaviest weight boys had mean daily intakes of niacin that were greater than the recommendations.

To 14 years the heaviest weight girls had mean daily niacin intakes greater than those of the lightest weight girls except for the 9- and 10-year-olds. From 15 to 18 years the heaviest weight girls had dietary niacin values less than those observed for the lightest weight girls.

The girls of medium weight had niacin values that either exceeded or met the allowances, whereas the lightest weight girls had niacin intakes below the allowances at several ages. The heaviest weight girls had diets with niacin values that either exceeded or approximated the allowances from 6 to 16 years; afterwards the values declined to nearly 2 milligrams below the recommendations.

It may be noted from Tables 26 and 27 that the girls of heaviest weight had diets with mean energy food value and nutrient contents that were in general larger than those observed for the girls of lightest weight from 6 to 13 years; afterwards the relative positions were reversed. The diets of the teen-age girls of heaviest weight were poorer than those of the girls of lightest weight or of medium weight in all respects except ascorbic acid. The overweight girls may have been attempting to reduce their intake of food. The diets of these girls may be expected to lead to an unfavorable nitrogen balance, since the caloric intake and the protein content of the diets were below the allowances. Leverton (1951) observed that college girls could not maintain nitrogen balance on a low protein intake, if the caloric value of the diets did not meet the energy needs of the girls.

Since the Iowa girls had an insufficient intake of protein, calcium and riboflavin, it appeared that milk was not liberally used by the girls.

<u>Concentrations of various blood constituents</u>. The serum ascorbic acid concentrations of the three groups of boys and girls classified according to weight tended to decline with age to a low level in the middle teens. Some of the poorest concentrations were observed among the heaviest weight boys and girls. These low concentrations are not associated with especially low intakes of vitamin C. At 14 years the heaviest weight boys and girls had a calculated mean ascorbic acid intake of 60 and 90 milligrams, respectively, and a mean serum concentration of 0.3 and 0.2 milligram. The low serum ascorbic acid concentrations at 14 years for the overweight boys and girls and at 15 years for the lightest weight and medium weight boys and girls are noteworthy (see Figure 7).

The heaviest weight children may be utilizing the vitamin more rapidly in the formation of new tissues, so the decrease occurred a year earlier, than for the lightest and medium weight children who are accumulating tissue at a slower rate. The concentrations did not reach as low a level for the lightest and medium weight groups. The observation needs further study for the serum ascorbic acid concentration may not only reflect the rapid use of the vitamin by the body for tissue formation, but also the intake of the vitamin-C-rich foods over a period of time.

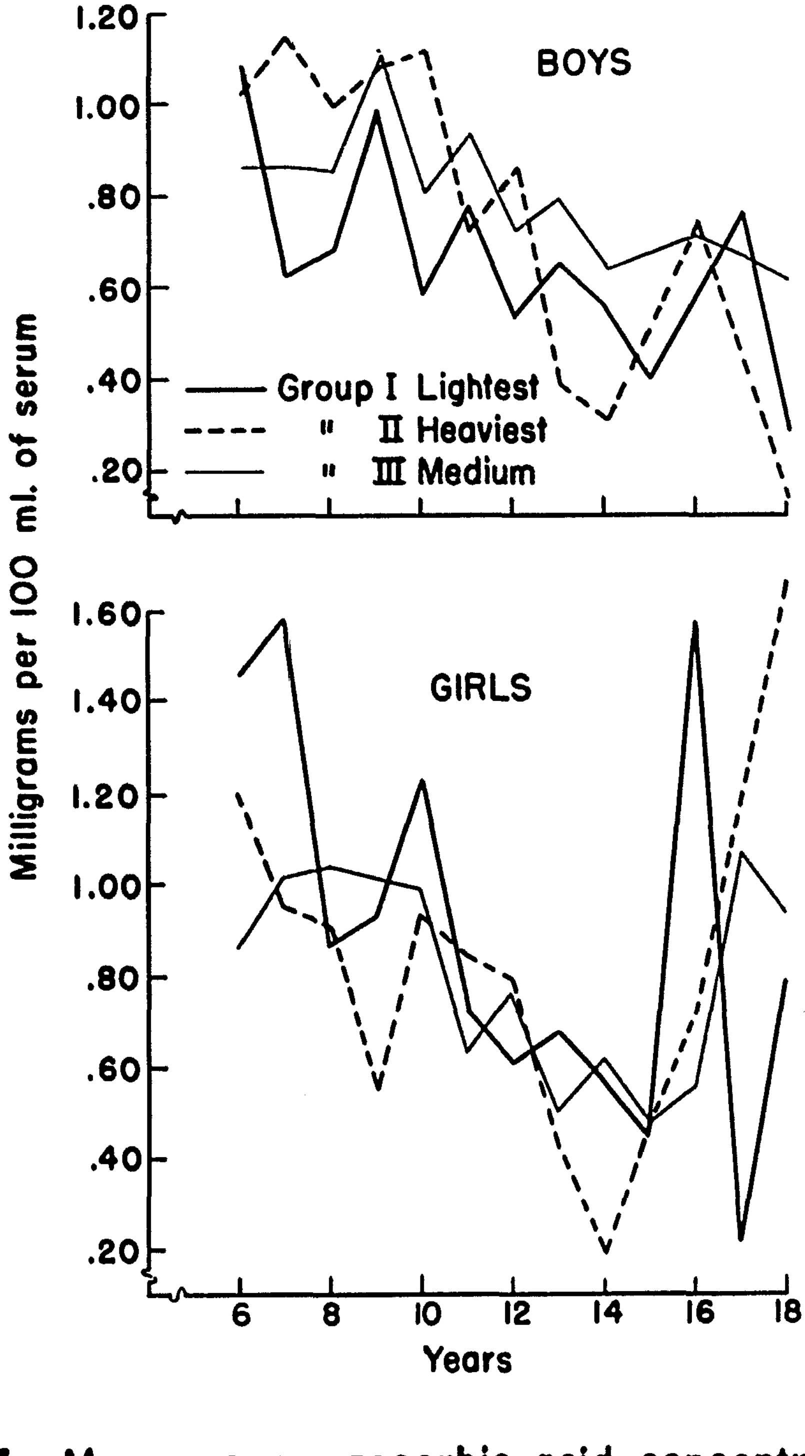


Fig. 7 Meam serum ascorbic acid concentrations of Iowa children classified according to three weight groups.

The boys of heaviest weight had serum concentrations that tended to be larger than those of the boys of lightest weight from 6 to 12 years. The boys of medium weight had concentrations that were nearly always larger than those of the boys of lightest weight (see Table 28). The girls of heaviest weight had serum ascorbic acid concentrations that tended to be lower than those of the girls of lightest weight. The boys and the girls of medium weight tended to have concentrations that varied less from age to age than did the concentrations of the other groups of boys and girls.

Bessey and Lowry (1947) suggested that 0.7 milligram per cent was satisfactory level of serum ascorbic acid concentration for boys and girls. The boys of heaviest weight had concentrations 0.7 milligram per cent or higher from 6 to 12 years. The boys of lightest weight had mean concentrations that were below 0.7 milligram per cent, except for 6, 9 and 11 years. The boys of medium weight had concentrations of 0.7 milligram or better through 13 years.

The girls of heaviest weight had concentrations above 0.7 milligram per cent except at 9, 13, 14 and 15 years. From 6 to 11 years the girls of lightest weight had serum ascorbic acid concentrations above 0.7 milligram per cent, then followed a decline which reached a low level of 0.2 milligram per cent. The concentrations of the girls of medium weight were above 0.7 milligram per cent to 10 years, then

Table 28

Mean Serum Ascorbic Acid Concentration of Iowa Children Classified According to Weight Groups

Groups[a]	I		II		III	
Age yr.	No.	Mg.%	No.	Mg.%	No.	Mg.%
			Boys			
6	3	1.08	3	1.02	15	0.86
7	2	0.62	2	1.15	21	0.86
8	2	0.68	4	0.99	31	0.85
9	7	1.00	5	1.08	23	1.09
10	4	0.58	3	1.11	25	0.80
11	2	0.78	4	0.72	18	0.93
12	7	0.53	10	0.86	47	0.72
13	2	0.65	5	0.38	20	0.79
14	5	0.56	3	0.31	9	0.64
15	1	0.40	1	0.52	12	0.50
16	2	0.60	3	0.74	10	0.71
17	1	0.76	2	0.36	4	0.67
18	2	0.28	1	0.13	7	0.61
			Girls			
6	2	1.45	3	1.20	19	.86
7	2	1.58	4	0.95	25	1.02
8	4	0.87	5	0.91	15	1.04
9	9	0.93	4	0.56	24	1.02
10	2	1.23	4	0.93	22	0.99
11	6	0.73	9	0.84	19	0.63
12	12	0.61	6	0.79	43	0.76
13	2	0.68	3	0.42	20	0.50
14	1	0.58	1	0.19	11	0.62
15	4	0.44	3	0.47	8	0.48
16	1	1.57	4	0.72	10	0.56
17	1	0.22	2	1.20	7	1.07
18	2	0.80	1	1.66	4	0.94

[a]Group I--Weights minus 2 or 3 standard deviations
Group II--Weights plus 2 or 3 standard deviations
Group III--Weights within ± 1 standard deviations

they declined to 0.2 milligram per cent at 15 years. In the next three years the concentrations were erratic in trend. The girls of medium weight had concentrations that were above 0.7 milligram per cent to 10 years, then they declined steadily to 15 years.

From these data, it appeared that the amount of vitamin C recommended as an adequate intake by the National Research Council was not sufficient to produce a mean blood concentration equal to 0.7 milligram per cent at all ages. Also in view of the deviations noted with age, the question is raised as to whether 0.7 milligram per cent is a satisfactory level for children of all weights and ages.

The decrease with age in the serum carotenoid concentration of the three groups of boys and girls may have a physiological significance. This trend was particularly outstanding for the children of heaviest weight (see Figure 8). The low concentrations were attained by the boys in the three groups at 15 years and by the girls of heaviest and medium weight at 13 years. Since the disappearance of the carotenoids in the blood may be associated with the conversion to vitamin A these observations suggested the greater use of vitamin A by rapidly growing children than by the less rapidly growing children.

The boys of heaviest weight had serum carotenoid concentrations that were higher than those of boys of lightest weight

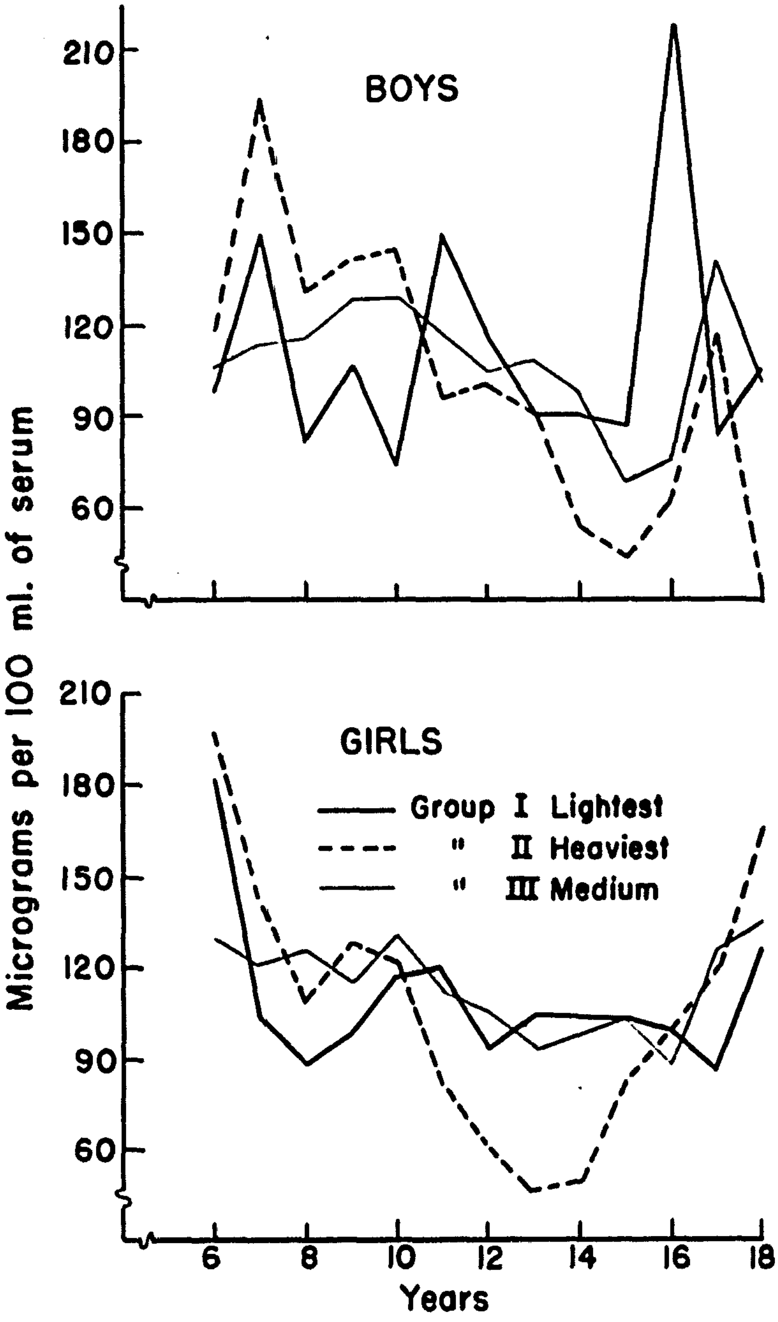


Fig. 8 Mean serum carotenoid concentrations of Iowa children classified according to three weight groups.

10 years; from 11 to 18 the values tended to be lower (see Table 29).

The girls of heaviest weight had serum carotenoid concentrations greater than those of the girls of lightest weight from 6 to 10 years; afterwards the order was reversed to 16 years. The girls of medium weight had concentrations that conformed more closely to those of the girls of lightest weight than those of girls of the heaviest weight.

The mean serum alkaline phosphatase concentrations of the children of lightest weight and of heaviest weight fluctuated more than the concentrations of the children of medium weight (see Figure 9). The decline toward adult levels began at 13 years for the boys of lightest weight and of medium weight, but at 12 years for the boys of heaviest weight. The descent toward adult levels was more rapid for the boys of heaviest weight than for the boys in the other two groups. The boys of medium weight had values that decreased regularly toward the adult levels while the other two groups fluctuated during the decline (see Table 30).

From 6 to 10 years the girls had phosphatase concentrations that corresponded to weight status. The girls of heaviest weight reached the peak at 10 years, the girls of medium weight at 11 years, and the girls of lightest weight at 12 years. It appears from these data that with the girls the concentration of phosphatase may be associated

Table 29

Mean Serum Carotenoid Concentrations of Iowa Children Classified According to Weight Groups

Groups[a]	I		II		III	
Age yr.	No.	Mcg.%	No.	Mcg.%	No.	Mcg.%
			Boys			
6	4	98	3	118	14	106
7	3	148	2	194	20	114
8	2	82	4	130	28	116
9	6	108	5	141	20	128
10	4	74	3	145	27	129
11	1	150	4	96	21	118
12	8	115	9	100	48	105
13	2	90	5	91	19	109
14	5	91	3	54	9	99
15	1	86	1	44	12	68
16	1	218	3	62	9	75
17	2	84	2	116	3	142
18	2	107	1	33	7	102
			Girls			
6	4	181	3	198	17	129
7	2	102	4	142	25	121
8	4	87	5	110	15	125
9	8	97	5	128	25	115
10	2	116	4	122	22	130
11	6	120	9	81	20	112
12	11	92	5	60	46	105
13	2	104	3	46	20	93
14	0	--	1	49	12	99
15	4	103	3	81	8	103
16	1	98	4	100	9	88
17	1	86	2	119	7	125
18	2	126	1	165	4	134

[a]Group I--Weights minus 2 or 3 standard deviations
Group II--Weights plus 2 or 3 standard deviations
Group III--Weights within ± 1 standard deviations

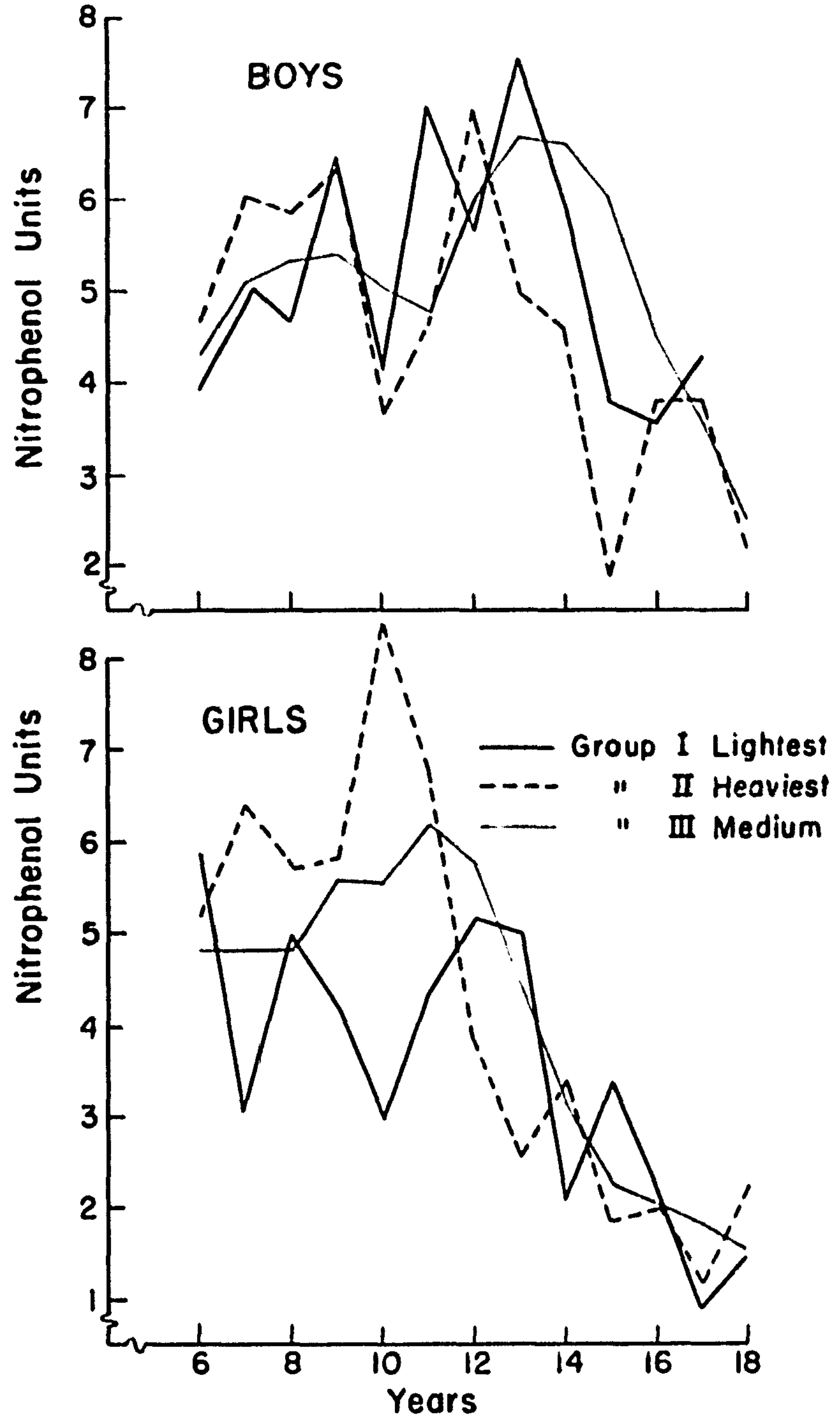


Fig. 9 Mean serum alkaline phosphatase concentration of Iowa children classified according to three weight groups.

Table 30

Mean Serum Alkaline Phosphatase Concentrations of Iowa Children Classified According to Weight Groups

Groups[a]	I		II		III	
Age yr.	No.	NP.U.[b]	No.	NP.U.[b]	No.	NP.U.[b]
			Boys			
6	4	3.90	3	4.32	15	4.63
7	3	5.03	2	6.02	23	5.11
8	2	4.64	4	5.85	31	5.35
9	7	6.41	5	6.34	23	5.42
10	4	4.17	3	3.65	28	5.05
11	2	7.00	4	4.58	20	4.75
12	8	5.68	10	6.95	47	5.95
13	2	7.54	5	4.97	19	6.68
14	5	5.86	3	4.59	9	6.57
15	1	3.78	1	1.89	12	5.96
16	2	3.53	3	3.78	10	4.48
17	1	4.30	2	3.81	4	3.64
18	2	2.45	1	2.19	7	2.47
			Girls			
6	3	4.95	3	5.18	21	4.85
7	2	3.02	4	6.40	26	4.84
8	4	4.94	5	5.70	15	4.87
9	9	4.18	5	5.81	25	5.60
10	2	2.95	4	8.04	23	5.55
11	6	4.37	8	6.74	19	6.21
12	12	5.15	6	3.83	46	5.80
13	2	4.98	2	2.53	21	4.41
14	1	2.10	1	3.38	12	3.17
15	4	3.42	2	1.82	9	2.27
16	1	2.20	4	1.94	10	2.04
17	1	0.89	2	1.15	7	1.80
18	2	1.46	1	2.22	4	1.56

[a]Group I--Weights minus 2 or 3 standard deviations
Group II--Weights plus 2 or 3 standard deviations
Group III--Weights within ± 1 standard deviations

[b]Nitrophenol units.

with weight. To the time that the concentrations reached a peak the girls of heaviest weight had the highest concentrations, the girls of medium weight the intermediate and the girls of lightest weight the lowest. The peak was reached at 10 years by the girls of heaviest weight, at 11 years by the girls of medium weight and at 12 years by the girls of lightest weight.

The hemoglobin concentrations in the blood of the boys of lightest weight were in general lower than the values for the boys of heaviest weight or of medium weight (see Figure 10). The latter two groups had concentrations that were about the same. The girls did not exhibit a well-defined difference between the groups with the heaviest weight and lightest weight as did the boys. After 12 years the girls of average weight tended to have higher hemoglobin concentrations than had the other two groups. The lower hemoglobin concentration of the girls of heaviest weight at 13 years may be associated with the poor diets, previously described for this group.

The differences in nutrient intake and in serum concentrations of the various blood constituents and in physical status that have been noted in the three groups cannot be explained by age, for the difference between the children of lightest weight and of heaviest weight ranged from five months to no difference. The maximum difference five months occurred twice, namely, for the 9-year-old boys and

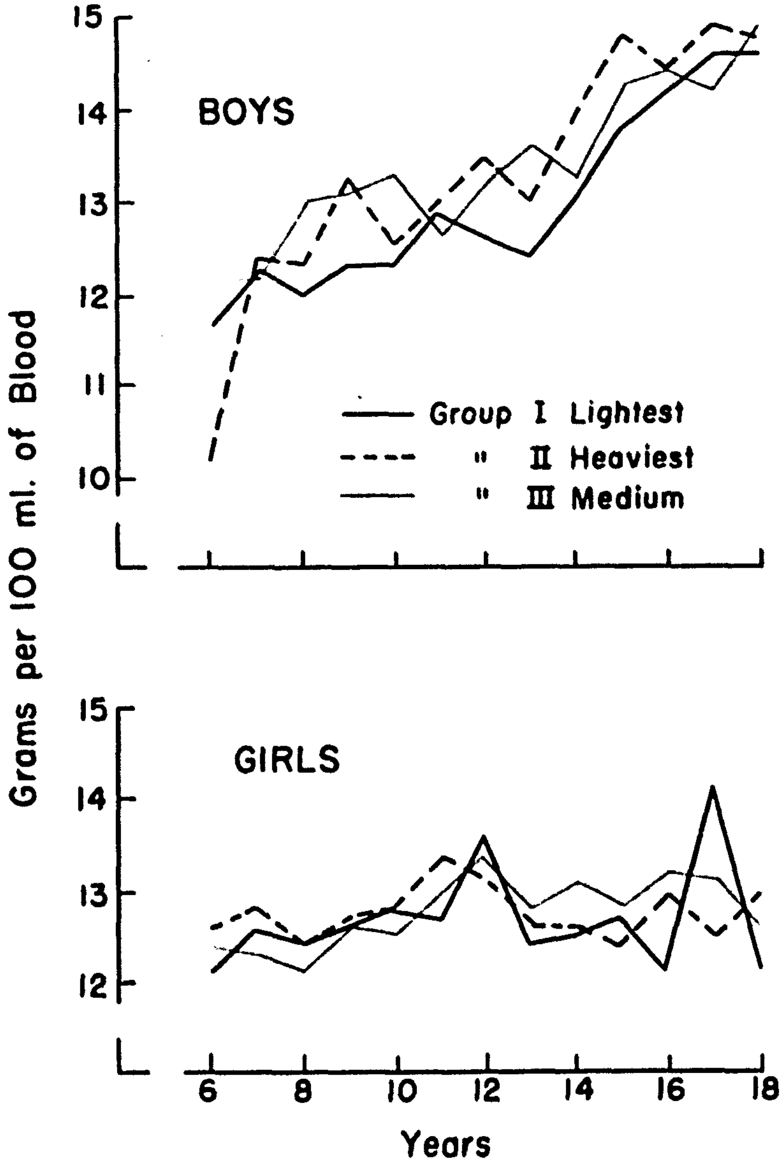


Fig. 10 Mean hemoglobin concentration in blood of Iowa children classified according to three weight groups

Table 31

Mean Hemoglobin Concentrations of Blood of Iowa Children Classified According to Weight Groups

Groups[a]	I		II		III	
Age yr.	No.	Gm.%	No.	Gm.%	No.	Gm.%
Boys						
6	5	11.6	3	10.1	28	12.2
7	4	12.3	4	12.4	48	12.2
8	2	12.0	5	12.3	44	13.0
9	7	12.3	7	13.3	38	13.1
10	7	12.3	6	12.5	47	13.3
11	3	12.9	6	13.0	39	12.6
12	12	12.6	12	13.5	62	13.2
13	6	12.4	6	13.0	30	13.6
14	6	13.0	7	14.0	28	13.3
15	4	13.8	5	14.8	23	14.3
16	3	14.2	3	14.4	28	14.4
17	2	14.6	2	14.9	17	14.2
18	2	14.6	4	14.8	12	14.9
Girls						
6	6	12.1	5	12.6	37	12.4
7	3	12.6	6	12.8	38	12.3
8	6	12.4	5	12.4	27	12.1
9	9	12.6	10	12.7	40	12.6
10	6	12.8	10	12.8	43	12.5
11	10	12.7	11	13.4	36	13.0
12	13	13.6	8	13.1	57	13.5
13	6	12.4	6	12.6	32	12.8
14	5	12.5	8	12.6	24	13.1
15	5	12.7	9	12.4	24	12.8
16	4	12.1	6	13.0	26	13.2
17	2	14.2	5	12.5	18	13.1
18	2	12.1	2	13.0	8	12.6

[a]Group I--Weight minus 2 or 3 standard deviations
Group II--Weight plus 2 or 3 standard deviations
Group III--Weight within ± 1 standard deviations

10-year-old girls. The average difference for the boys was two and one-half months; and for the girls two months.

Summary

1. In height the girls and boys of heaviest weight were the tallest, those of medium weight were intermediate, and those of lightest weight, the shortest.

2. With a few exceptions the boys of heaviest weight had diets with food energy and nutrient contents that were greater than those observed for the boys of lightest weight.

3. In general, the girls from 6 to 13 years of the heaviest weight group had dietary intakes of the various nutrients that were greater than those of the girls of the lightest weight. From 13 to 18 years the girls of heaviest weight had dietary intakes that were lower than the intakes of the girls of lightest weight.

4. There were some exceptions at the various ages, but in general, the boys and the girls with medium weight tended to have dietary intakes of the various nutrients that were intermediate to the intakes of the other two groups.

5. The boys of medium weight had diets which either exceeded or approximated the allowances for food energy and the dietary nutrients. The greatest deviation was in the mean calcium intake.

6. The girls of medium weight to 13 years had mean intakes that either exceeded or approximated the allowances except for thiamine and calcium.

7. The boys of heaviest weight and the girls of heaviest weight to 13 years tended to have mean nutrient intakes that either surpassed or approximated the suggested allowances. The older girls of heaviest weight had diets with mean food energy and nutrient values less than the allowances, except ascorbic acid.

8. Except for calcium, the boys of lightest weight and the girls of lightest weight from 6 to 13 years tended to have more age groups with dietary intakes of the various nutrients that were less than the allowances, than did the other two groups of children. With the exception of calcium the girls of lightest weight from 13 to 18 years had intakes of the various nutrients that were nearly always better than the allowances.

9. The serum ascorbic acid concentrations of the girls and boys in the three weight groups tended to decrease with age until they reached a low level at 14 years for the childrend of heaviest weight, and at 15 years for the children of lightest weight and of medium weight. The variations in serum ascorbic acid concentrations from age to age was most evident with the children of heaviest weight.

10. The serum carotenoid concentration apparently decreased with age, so that the lowest concentration was observed in the heaviest weight boys and girls at 13 and 15 years, respectively.

11. The peak alkaline phosphatase concentration was reached by the heaviest weight boys at 12 years, and by the lightest weight and medium weight boys at 13 years. The descent to adult levels was more rapid for the heaviest weight boys than for the other two groups.

12. The peak of the mean serum alkaline phosphatase concentrations was reached by the heaviest weight girls at 10 years, by the girls of average weight at 11 years and by the lightest weight girls at 12 years. The decline toward adult level was rapid for the heaviest weight girls.

13. The mean hemoglobin concentration in the blood of the lightest weight boys was lower than the mean concentrations for the other two groups of boys. There was very little difference between the hemoglobin concentrations of the medium weight and heaviest weight boys. The hemoglobin concentrations of the three groups of girls displayed no outstanding differences.

Heights of Iowa Children

Height is a measure of linear growth. An increase of one inch does not mean an increase throughout the length of the body. It may be an increase in the area of the head and neck, in the trunk, or in the leg. The place where this gain in height takes place depends largely on the age at which the gain in height is made.

Inherited tendencies influence the ultimate expression of linear growth. Tallness is dominant over shortness. The children of tall parents tend to be tall and children of short parents, short. This family trait will be most evident at periods of rapid growth (Winchester, 1951).

Like weight measurements, the height measurements are subject to variations. The time of day is another important factor that induces a variation in height. If the heights of children are to be observed over a period of time, in order to have comparable data, the height measurements should be made at the same time of day. Children are shorter at noon than they are upon rising, and still shorter in the evening than at noon (Boyd, 1929). It is also very important to make the measurement as accurately as possible. The techniques used should be standardized and employed carefully so that the difference due to the way the measurement is made is at the minimum

Mean heights of total sample of Iowa children

The children in this study were measured in the later half of the morning. Heights were measured against a paper scale which was glued against an upright board placed at right angles to a platform. The scale was prepared by the Iowa Child Welfare at the University of the State of Iowa. A right-angle head piece was used to determine the point on the measuring scale on the level with the highest point of the child's head.

The boys made the greatest height increment between the ages of 12 and 13 years and between 14 and 15 years. The variation in the individual observations at these ages became quite large, and remained highly variable through 18 years (see Table 32). The girls made the greatest increment between 8 to 10 years and 13 to 14 years. The variations among the individual observations on the heights of girls at each age increased to 10 years, then declined slowly so the ranges of heights for girls were about the same at each age from 14 to 18 years.

Comparison of the heights of Iowa children with those of other studies

The boys in this study, who were selected randomly from a large population of Iowa school-age boys, were

Table 32

Mean Heights of the Iowa Children

Age yr.	No.	Mean cm.	Standard deviation cm.	Standard error cm.	Range cm.
			Boys		
6	38	118	4.7	0.7	109 - 126
7	58	124	5.2	0.7	113 - 137
8	53	131	5.5	0.8	121 - 145
9	55	136	6.2	0.8	122 - 149
10	60	140	5.8	0.7	127 - 153
11	50	144	6.6	0.9	126 - 159
12	90	148	7.1	0.8	127 - 169
13	44	156	8.6	1.3	129 - 172
14	40	161	10.1	1.6	133 - 176
15	32	171	6.5	1.1	158 - 187
16	34	170	7.3	1.2	150 - 184
17	21	173	7.5	1.6	156 - 187
18	18	172	8.8	2.1	157 - 187
			Girls		
6	50	118	4.8	0.7	106 - 126
7	48	123	6.4	0.9	112 - 134
8	44	127	5.5	0.8	116 - 142
9	64	133	6.6	0.8	118 - 148
10	61	141	7.3	0.9	124 - 159
11	58	146	7.6	1.0	131 - 162
12	82	151	7.1	0.8	137 - 169
13	44	153	7.5	1.1	138 - 168
14	37	159	5.1	0.8	149 - 170
15	38	161	6.7	1.1	147 - 175
16	37	161	5.6	0.9	147 - 175
17	26	162	4.8	0.9	154 - 171
18	12	163	6.5	1.9	154 - 174

taller than the boys observed by Jackson and Kelly at Iowa City (see Table 33). These boys were also taller than the Iowa boys measured by the Bureau of Human Nutrition and Home Economics (1941). The Iowa boys in this study were not so tall as the Chicago boys observed by Gray and Ayres (1931) and the Denver boys measured by Maresh (1948).

The Iowa girls in this random sample of school age girls were taller than the girls measured at Iowa City (Jackson and Kelly, 1945) or by the Bureau of Human Nutrition and Home Economics (1941) (see Table 34). They tended to be shorter than the girls measured at Chicago by Gray and Ayres (1931) and at Denver by Maresh (1948).

Study of the tallest, shortest and average height children

To study the dietary intake and the blood constituents of children of different heights, each age-sex group was divided into three groups according to the mean and standard deviation of the group. The children in Group I consisted of girls and boys whose heights were in the second or third standard deviations below the mean for the mean for the 13 age-sex group, Group II contained children whose heights were in the second or third standard deviations above the means and Group III contained the children who were within plus or minus one standard deviation.

Table 33

Comparison of Mean Heights of Iowa School Children with Similar Data fr

Boys

Age in yrs.	Iowa (1953)[a] No.	Iowa (1953)[a] Mean	Iowa (1953)[a] s.d.	Iowa (1941)[b] No.	Iowa (1941)[b] Mean	Iowa (1941)[b] s.d.	Iowa (1945)[c] No.	Iowa (1945)[c] Mean	Iowa (1945)[c] s.d.	Chicag No.	M
		cm	cm		cm	cm		cm	cm		(
6	38	117.5	4.74	417	116.8	5.34	-	116.1	4.06	114	11
7	58	124.1	5.22	429	122.5	5.04	-	121.9	5.08	143	12
8	53	130.9	5.50	544	128.4	5.56	-	128.0	6.10	147	13
9	55	135.6	6.22	483	133.6	5.94	-	133.6	5.59	167	13
10	60	139.5	5.76	554	137.6	6.94	-	138.9	5.59	173	14
11	50	144.1	6.56	501	143.1	6.71	-	143.2	6.10	201	14
12	90	148.3	7.12	321	147.1	7.72	-	147.8	6.35	247	15
13	44	156.5	8.63	229	153.1	8.16	-	153.2	7.62	293	15
14	40	160.7	10.11	168	160.3	8.49	-	159.3	8.64	373	16
15	32	171.1	6.51	-	-	-	-	165.1	8.64	362	16
16	34	170.4	7.32	-	-	-	-	169.7	7.62	292	17
17	21	172.8	7.52	-	-	-	-	173.5	7.62	229	17
18	18	172.4	8.82	-	-	-	-	174.2	8.64	129	17

[a]Present study

[b]U.S.D.A. miscellaneous publication No. 366

[c]Jackson and Kelly (1945)

[d]Gray and Ayres (1931)

[e]Maresh (1948)

Table 33

Heights of Iowa School Children with Similar Data from Selected Studies

Boys

owa (1941)[b]		Iowa (1945)[c]			Chicago (1931)[d]			Denver (1948)[e]		
Mean	s.d.	No.	Mean	s.d.	No.	Mean	s.d.	No.	Mean	s.d.
cm	cm		cm	cm		cm	cm		cm	cm
116.8	5.34	-	116.1	4.06	114	118.6	4.85	175	120.7	4.20
122.5	5.04	-	121.9	5.08	143	124.7	5.23	164	127.3	4.39
128.4	5.56	-	128.0	6.10	147	131.1	5.28	169	132.7	4.66
133.6	5.94	-	133.6	5.59	167	135.8	5.81	164	137.8	4.74
137.6	6.94	-	138.9	5.59	173	141.2	5.13	151	142.4	4.90
143.1	6.71	-	143.2	6.10	201	145.4	6.62	142	146.7	5.42
147.1	7.72	-	147.8	6.35	247	150.3	6.74	135	151.9	5.67
153.1	8.16	-	153.2	7.62	293	156.4	7.29	123	158.0	6.54
160.3	8.49	-	159.3	8.64	373	162.4	7.79	97	164.9	6.84
-	-	-	165.1	8.64	362	168.5	7.73	71	170.6	6.41
-	-	-	169.7	7.62	292	172.8	6.71	48	175.2	5.11
-	-	-	173.5	7.62	229	175.2	6.14	39	176.4	4.59
-	-	-	174.2	8.64	129	176.1	6.39	58	179.5	6.35

on No. 366

Table 34

Comparison of Mean Heights of Iowa School Children with Similar Data

Girls

Age in yrs.	Iowa (1953)[a] No.	Mean	s.d.	Iowa (1941)[b] No.	Mean	s.d.	Iowa (1945)[c] No.	Mean	s.d.	Ohi No.
		cm	cm		cm	cm		cm	cm	
6	50	117.8	4.85	445	116.3	4.90	-	115.1	4.32	74
7	48	122.6	6.44	535	121.9	5.17	-	120.9	5.33	90
8	44	126.7	5.48	492	127.8	6.14	-	126.7	5.33	100
9	64	133.4	6.64	539	132.7	6.21	-	132.6	5.84	122
10	61	140.8	7.34	542	138.3	6.58	-	137.7	5.84	110
11	58	146.0	7.56	540	144.1	7.00	-	143.5	6.60	139
12	82	151.4	7.09	323	149.9	7.22	-	150.4	7.11	126
13	44	153.2	7.48	181	153.9	7.21	-	156.0	6.35	124
14	37	159.4	5.14	134	158.6	6.23	-	159.5	5.59	108
15	38	161.2	6.66	-	-	-	-	160.8	4.83	96
16	37	160.5	5.59	-	-	-	-	161.3	5.33	86
17	26	162.5	4.79	-	-	-	-	161.3	6.10	86
18	12	163.2	6.54	-	-	-	-	161.0	6.10	51

[a]Present study

[b]U.S.D.A. Miscellaneous Publications No. 366

[c]Jackson and Kelly (1945)

[d]Gray and Ayres (1931)

[e]Maresh (1948)

Table 34

ı Heights of Iowa School Children with Similar Data from Selected Studies

Girls

Iowa (1941)[b]		Iowa (1945)[c]			Chicago (1931)[d]			Denver (1948)[e]		
Mean	s.d.	No.	Mean	s.d.	No.	Mean	s.d.	No.	Mean	s.d.
cm	cm		cm	cm		cm	cm		cm	cm
116.3	4.90	-	115.1	4.32	74	118.0	4.48	145	120.6	5.36
121.9	5.17	-	120.9	5.33	90	124.1	4.76	146	126.5	5.96
127.8	6.14	-	126.7	5.33	100	130.7	5.62	136	132.7	5.76
132.7	6.21	-	132.6	5.84	122	135.9	5.90	118	138.6	6.32
138.3	6.58	-	137.7	5.84	110	140.2	6.09	104	144.1	7.20
144.1	7.00	-	143.5	6.60	139	146.0	6.99	100	150.3	7.65
149.9	7.22	-	150.4	7.11	126	152.0	7.47	93	156.4	7.50
153.9	7.21	-	156.0	6.35	124	157.2	7.24	92	161.7	6.73
158.6	6.23	-	159.5	5.59	108	160.1	6.82	73	165.2	5.69
-	-	-	160.8	4.83	96	163.0	5.89	43	166.4	5.89
-	-	-	161.3	5.33	86	162.9	5.41	34	167.3	5.35
-	-	-	161.3	6.10	86	163.9	6.24	21	165.9	4.45
-	-	-	161.0	6.10	51	163.7	3.93	28	165.8	3.90

ions No. 366

__Physical status__. It may be observed in Figures 11 and 12 that the children in Group I were short, in Group II were tall, and in Group II, average according to the growth charts prepared from the data observed at the Iowa Child Welfare Research Station. In the following discussion Group I will be referred to as the "shortest", Group II as the "tallest", and Group III as "average".

In all age-sex groups the tallest children weighed more than the shortest children (see Table 35). Except for the 16 year old girls, the average children had mean intermediate weights to the mean weights of the other two groups. The shortest girls from 14 through 15 years apparently were heavy for their height. The mean heights for the short girls (14 to 17 years) were below the minus one standard deviation and the weights were between the 16th and 84th percentile (see Figure 12). The mean heights of the girls in Group III were close to the mean on the chart, but the weights were above the median weight on the chart, therefore this group of girls tended to be a little heavy for their height. To a less marked degree the boys indicated the same tendencies.

Figure 11. The heights and weights of Iowa boys classified according to three height groups.

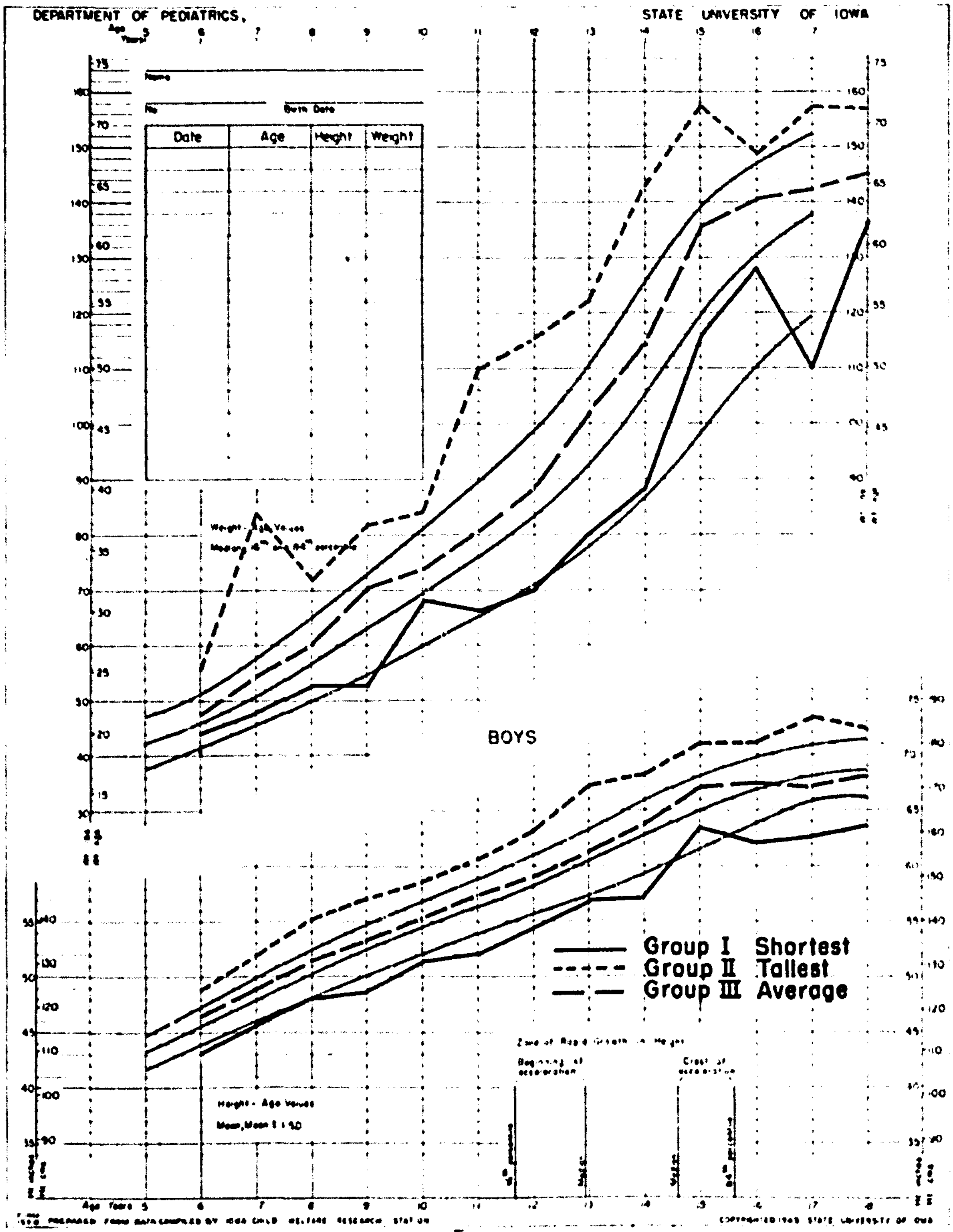

DEPARTMENT OF PEDIATRICS,
STATE UNIVERSITY OF IOWA
Date
Age
Height
Weight
BOYS
Group I Shortest
Group II Tallest
Group III Average
Height - Age Values
Mean, Mean ± 1 SD
Age Years

Figure 12. The heights and weights of Iowa girls classified according to three height groups.

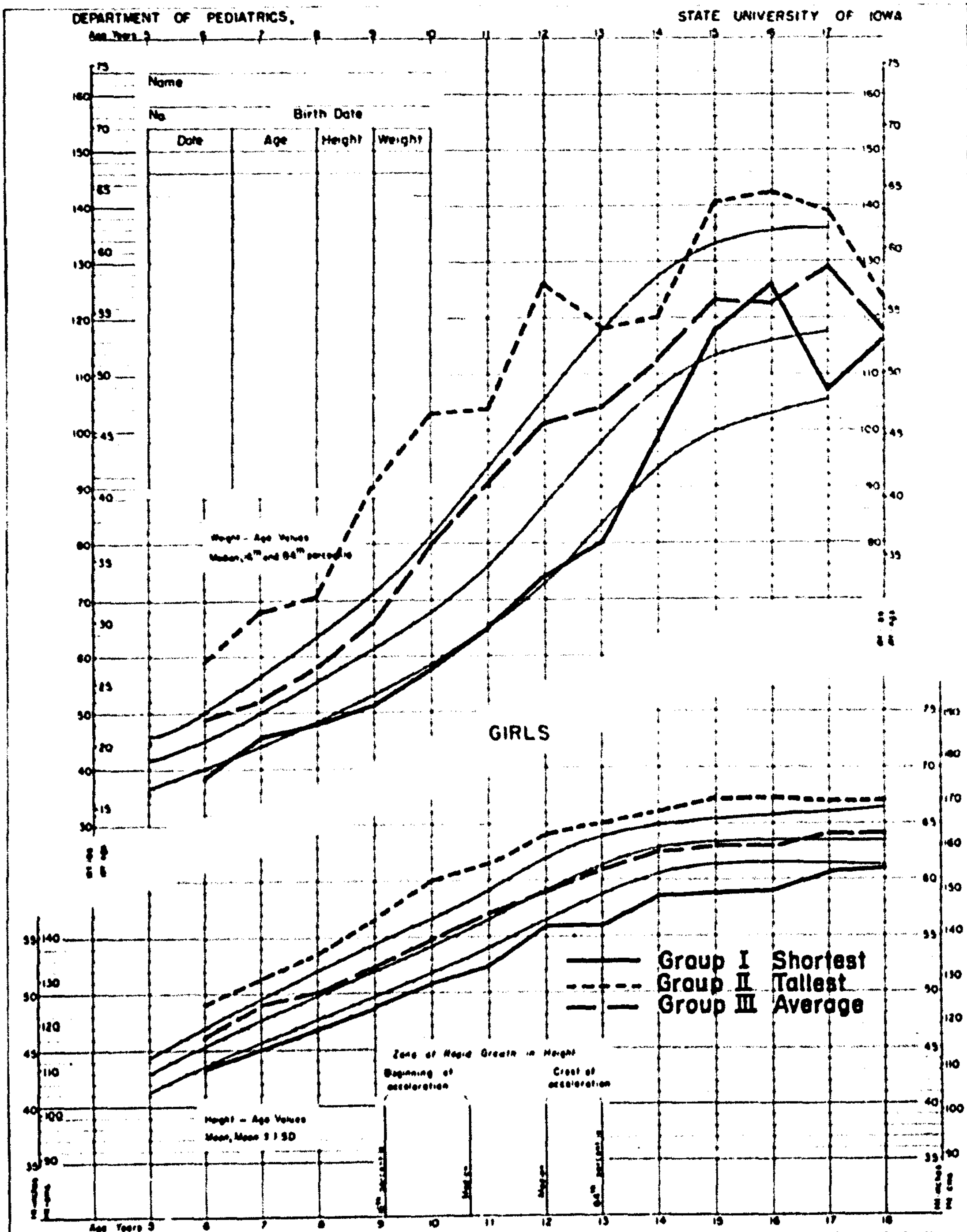

DEPARTMENT OF PEDIATRICS,
STATE UNIVERSITY OF IOWA
Name
No.
Birth Date
Date
Age
Height
Weight
GIRLS
Group I Shortest
Group II Tallest
Group III Average
Zone of Rapid Growth in Height
Beginning of acceleration
Crest of acceleration
Height - Age Values
Mean, Mean ± 1 SD
Age Years
PREPARED FROM DATA COMPILED BY IOWA CHILD WELFARE RESEARCH STATION

Table 35

Mean Weights of Iowa Children Classified According to Height Groups

Groups[a]	I		II		III	
Age yr.	No.	Kg.	No.	Kg.	No.	Kg.
			Boys			
6	6	19.8	11	25.8	20	21.8
7	9	21.9	12	38.2	35	24.7
8	6	24.1	10	33.1	36	27.5
9	5	24.1	8	37.0	40	32.1
10	10	31.0	8	38.3	42	33.4
11	7	29.9	8	50.4	35	36.6
12	14	32.1	14	52.8	62	40.0
13	2	36.1	6	55.3	35	46.3
14	8	40.0	6	64.9	26	51.8
15	5	52.6	5	71.9	22	61.4
16	5	58.4	5	67.6	22	63.9
17	2	49.5	2	71.4	17	64.6
18	4	61.9	4	71.1	9	65.7
			Girls			
6	7	17.5	6	26.4	37	22.2
7	6	20.6	10	29.9	32	23.8
8	6	21.8	6	31.0	32	26.2
9	9	23.1	10	40.3	42	30.0
10	8	26.6	7	46.8	46	35.0
11	9	29.5	7	46.9	42	41.2
12	13	33.8	14	56.7	54	45.8
13	5	35.7	7	53.6	32	47.1
14	4	44.5	6	54.1	27	51.7
15	5	53.3	6	63.4	27	55.9
16	4	57.0	5	64.4	27	55.7
17	4	48.8	4	63.0	17	58.6
18	1	53.1	3	55.7	8	53.6

[a]Group I --Height minus 2 or 3 standard deviations
Group II --Height plus 2 or 3 standard deviations
Group III--Height within ± 1 standard deviations

Nutrient intake. In Tables 36 and 37 are presented the mean food energy value and nutrient content of the diets of the three groups of children classified according to the three levels of height.

In general the tallest boys tended to have diets with larger mean daily energy food values than the shortest. At certain ages the boys of average height had diets with food energy values that were between the corresponding values of the two other groups (see Figure 13). The tallest boys had diets with mean food energy values that either exceeded or approximated the allowances, whereas in this respect the shortest boys had diets below the allowances except at 6, 7, 8, 10 and 11 years of age. The boys of average height had diets with mean values that approximated the allowances at all ages, although they tended to be slightly higher to 11 years and slightly lower afterwards.

The differences between the mean energy value of the diets of the tallest and shortest girls were less consistent than those noted for the boys. The tallest girls to 12 years had diets with mean energy values above the allowances but afterwards they were equal to or less than the allowances. The shortest girls had mean energy values that were more often below the allowances than above. On the whole

Table 36

Mean Daily Food Energy Value and Nutrient Content of Di[ets] of Iowa Children Classified According to Three Height Gr[oups]

Boys

Age in yrs.	No.	Group[a]	Height cm.	Age in mos.	Food energy cal.	Protein gm.	Calcium mg.	Iron mg.	Ascor[bic] aci[d] mg.
6	6	I	110	76	2081	68	1111	9	93
	11	II	124	80	2216	67	1056	10	88
	20	III	116	78	2229	66	1049	9	73
7	9	I	117	88	2280	66	1068	10	74
	12	II	132	91	2250	69	1037	10	87
	35	III	123	89	2108	64	1012	9	69
8	7	I	124	101	2151	66	1040	9	64
	10	II	140	101	2406	74	1107	11	92
	36	III	130	101	2196	70	1114	10	75
9	5	I	124	112	2118	65	976	11	97
	8	II	145	116	2782	80	1157	12	77
	40	III	134	113	2402	74	1096	11	8[illegible]
10	10	I	131	126	2459	77	1031	12	7[illegible]
	8	II	149	127	2383	74	1025	12	9[illegible]
	42	III	140	125	2413	73	1047	11	7[illegible]
11	7	I	133	137	2562	77	1165	11	8[illegible]
	8	II	154	138	2998	100	1306	14	10[illegible]
	35	III	144	137	2538	75	1080	11	8[illegible]

[a]Groups	Heights
I	Minus 2 or 3 standard deviations
II	Plus 2 or 3 standard deviations
III	Within ± 1 standard deviation

Table 36

ean Daily Food Energy Value and Nutrient Content of Diets
f Iowa Children Classified According to Three Height Groups

Boys

Age in mos.	Food energy cal.	Protein gm.	Calcium mg.	Iron mg.	Ascorbic acid mg.	Thiamine mg.	Ribo-flavin mg.	Niacin mg.
76	2081	68	1111	9	93	1.1	1.9	11
80	2216	67	1056	10	88	1.1	1.8	11
78	2229	66	1049	9	73	1.0	1.9	11
88	2280	66	1068	10	74	1.0	1.9	12
91	2250	69	1037	10	87	1.0	1.9	12
89	2108	64	1012	9	69	1.0	1.8	11
101	2151	66	1040	9	64	1.1	1.9	10
101	2406	74	1107	11	92	1.2	2.0	13
101	2196	70	1114	10	75	1.1	2.0	11
112	2118	65	976	11	97	1.0	2.0	11
116	2782	80	1157	12	77	1.2	2.0	13
113	2402	74	1096	11	86	1.2	2.0	13
126	2459	77	1031	12	70	1.2	2.0	15
127	2383	74	1025	12	94	1.1	2.0	14
125	2413	73	1047	11	75	1.1	2.0	13
137	2562	77	1165	11	83	1.2	2.0	12
138	2998	100	1306	14	105	1.5	2.4	12
137	2538	75	1080	11	82	1.2	2.0	13

lard deviations

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Table 36 (continued)

Age in yrs.	No.	Group[a]	Height cm.	Age in mos.	Food energy cal.	Protein gm.	Calcium mg.	Iron mg.	Ascorb acid mg.
12	14	I	138	149	2557	80	927	12	69
	14	II	160	150	3099	96	1326	14	109
	62	III	148	149	2700	84	1136	13	82
13	3	I	145	158	2499	65	688	12	71
	6	II	170	162	3794	98	1396	14	77
	35	III	151	161	2778	84	1103	13	100
14	7	I	145	172	3041	89	976	14	76
	6	II	173	176	3219	94	1193	16	86
	26	III	162	174	3193	94	1127	14	100
15	5	I	162	185	3339	100	1106	16	106
	5	II	182	186	3413	100	1086	18	118
	22	III	165	186	3196	91	1213	15	90
16	4	I	158	200	3391	98	1272	17	122
	5	II	181	195	3633	102	1409	16	106
	22	III	164	196	3378	99	1300	15	109
17	2	I	159	207	2129	81	1144	10	96
	2	II	186	214	3870	111	1544	17	92
	17	III	172	208	3493	107	1464	17	103
18	4	I	161	224	3722	112	1091	17	79
	4	II	183	224	3333	100	1291	14	88
	9	III	173	222	3773	112	1295	17	96

ge n os.	Food energy cal.	Protein gm.	Calcium mg.	Iron mg.	Ascorbic acid mg.	Thiamine mg.	Ribo-flavin mg.	Niacin mg.
49	2557	80	927	12	69	1.3	1.8	14
50	3099	96	1326	14	109	1.4	2.5	16
49	2700	84	1136	13	82	1.3	2.2	16
58	2499	65	688	12	71	1.1	1.4	11
62	3794	98	1396	14	77	1.4	2.5	12
61	2778	84	1103	13	100	1.3	2.2	15
72	3041	89	976	14	76	1.5	1.9	17
76	3219	94	1193	16	86	1.5	2.4	17
74	3193	94	1127	14	100	1.5	2.3	17
185	3339	100	1106	16	106	1.6	2.4	20
186	3413	100	1086	18	118	1.7	2.6	19
186	3196	91	1213	15	90	1.5	2.5	15
200	3391	98	1272	17	122	1.7	2.4	18
195	3633	102	1409	16	106	1.6	2.5	16
196	3378	99	1300	15	109	1.6	2.5	17
207	2129	81	1144	10	96	1.1	2.0	13
214	3870	111	1544	17	92	1.7	1.8	19
208	3493	107	1464	17	103	1.7	2.7	18
224	3722	112	1091	17	79	1.8	2.4	21
224	3333	100	1291	14	88	1.6	2.8	20
222	3773	112	1295	17	96	1.9	2.8	19

Table 37

Mean Daily Food Energy Value and Nutrient Content of Die[t]
of Iowa Children Classified According to Three Height Gr[oups]

Girls

Age in yrs.	No.	Group[a]	Height cm.	Age in mos.	Food energy cal.	Protein gm.	Calcium mg.	Iron mg.	Ascorbi[c] acid mg.
6	7	I	110	78	1757	55	838	9	60
	6	II	124	81	1932	61	1040	9	95
	37	III	118	78	1995	61	911	9	63
7	6	I	114	88	2086	61	829	10	66
	10	II	132	91	1884	62	913	9	79
	32	III	122	89	1975	60	879	9	78
8	6	I	118	99	1790	49	674	8	72
	6	II	136	101	2266	74	1236	11	107
	31	III	126	101	2023	64	1039	9	70
9	9	I	123	112	2367	71	927	11	84
	10	II	144	115	2341	75	1041	11	76
	43	III	133	114	2304	70	942	11	83
10	8	I	129	123	2108	63	820	11	78
	7	II	154	128	2330	74	1069	12	88
	46	III	141	125	2315	68	955	11	88
11	9	I	134	136	2030	62	800	10	75
	7	II	158	142	2698	82	1142	12	79
	42	III	147	137	2226	68	1021	10	81

[a]Groups	Heights
I	Minus 2 or 3 standard deviations
II	Plus 2 or 3 standard deviations
III	Within ± 1 standard deviation

Table 37

Daily Food Energy Value and Nutrient Content of Diets
wa Children Classified According to Three Height Groups

Girls

ge n os.	Food energy cal.	Protein gm.	Calcium mg.	Iron mg.	Ascorbic acid mg.	Thiamine mg.	Ribo-flavin mg.	Niacin mg.
78	1757	55	838	9	60	0.9	1.5	10
81	1932	61	1040	9	95	1.0	1.9	10
78	1995	61	911	9	63	1.0	1.7	10
88	2086	61	829	10	66	1.0	1.7	12
91	1884	62	913	9	79	1.0	1.6	10
89	1975	60	879	9	78	1.0	1.6	10
99	1790	49	674	8	72	0.9	1.3	9
.01	2266	74	1236	11	107	1.2	2.3	12
.01	2023	64	1039	9	70	1.0	1.8	10
.12	2367	71	927	11	84	1.1	1.9	13
115	2341	75	1041	11	76	1.1	2.0	12
114	2304	70	942	11	83	1.1	1.8	12
123	2108	63	820	11	78	1.1	1.7	12
128	2330	74	1069	12	88	1.2	2.1	14
125	2315	68	955	11	88	1.1	1.8	12
136	2030	62	800	10	75	1.1	1.7	11
142	2698	82	1142	12	79	1.3	2.1	15
137	2226	68	1021	10	81	1.1	1.9	12

deviations

deviations

deviation

Table 37 (continued)

Age in yrs.	No.	Group[a]	Height cm.	Age in mos.	Food energy cal.	Protein gm.	Calcium mg.	Iron mg.	Ascorb acid mg.
12	13	I	141	147	2730	82	1035	13	75
	14	II	162	150	2762	83	1139	13	106
	54	III	151	149	2492	78	1060	12	78
13	5	I	141	159	2067	66	1188	9	61
	7	II	165	162	2334	69	816	10	69
	32	III	153	161	2565	76	1039	12	80
14	4	I	151	171	2432	75	1174	12	80
	6	II	167	175	2626	79	1050	13	74
	27	III	159	172	2464	74	946	12	84
15	5	I	151	184	2297	70	890	12	79
	6	II	171	184	2449	73	865	11	57
	27	III	161	186	2684	76	909	12	103
16	4	I	152	194	2356	65	663	11	87
	5	II	171	199	2145	72	988	10	94
	27	III	160	198	2336	69	800	11	90
17	4	I	155	210	2123	64	834	10	67
	4	II	170	209	2645	84	1088	11	84
	17	III	163	209	2388	71	786	12	91
18	1	I	154	225	2738	80	734	15	86
	3	II	172	225	2719	80	861	12	103
	8	III	161	221	2361	71	786	11	90

s.	Food energy cal.	Protein gm.	Calcium mg.	Iron mg.	Ascorbic acid mg.	Thiamine mg.	Ribo-flavin mg.	Niacin mg.
7	2730	82	1035	13	75	1.3	2.1	14
0	2762	83	1139	13	106	1.3	2.2	15
9	2492	78	1060	12	78	1.2	2.0	14
9	2067	66	1188	9	61	1.0	1.6	11
2	2334	69	816	10	69	1.1	1.7	14
1	2565	76	1039	12	80	1.2	1.9	13
1	2432	75	1174	12	80	1.2	2.0	12
5	2626	79	1050	13	74	1.2	2.1	13
2	2464	74	946	12	84	1.2	1.9	13
4	2297	70	890	12	79	1.2	1.6	14
4	2449	73	865	11	57	1.1	1.7	12
6	2684	76	909	12	103	1.3	1.9	14
4	2356	65	663	11	87	1.1	1.4	11
9	2145	72	988	10	94	1.1	1.8	12
8	2336	69	800	11	90	1.2	1.6	12
10	2123	64	834	10	67	1.0	1.6	11
9	2645	84	1088	11	84	1.2	2.0	12
9	2388	71	786	12	91	1.2	1.6	13
25	2738	80	734	15	86	1.5	1.5	17
25	2719	80	861	12	103	1.3	1.8	16
21	2361	71	786	11	90	1.1	1.5	12

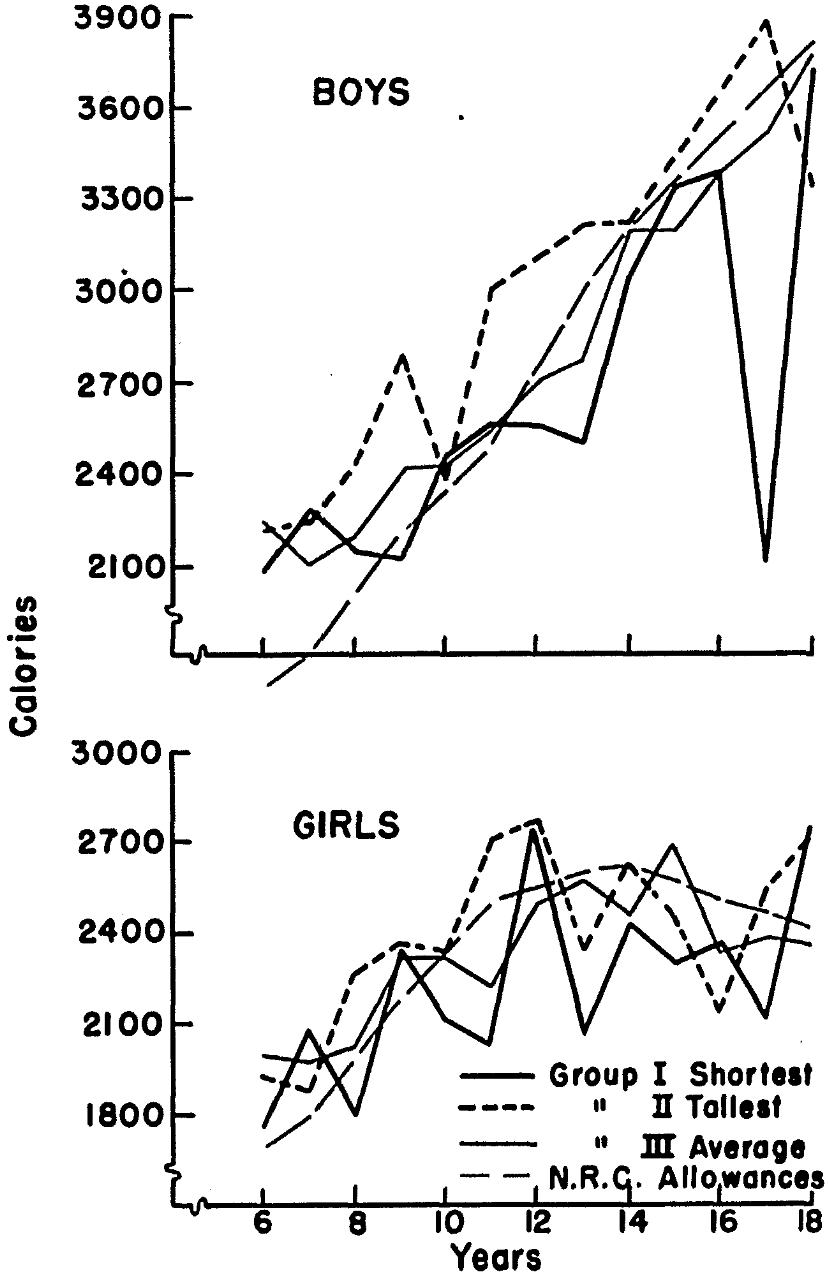

Fig. 13 Mean daily food energy value of the diets of Iowa children classified according to three groups of height.

the average girls had diets with energy values that approximated the allowances.

The tallest boys had mean daily protein intakes that were nearly always greater than those of the shortest boys. The boys of average height had protein intakes lower than those of the tallest boys. The mean protein content of the diets of the boys of average height and of the tallest boys were always greater than the allowances. The shortest boys had diets which exceeded the allowances except at 13 and 17 years (see Figure 14).

At corresponding ages that tallest girls always had mean daily protein intakes that were greater than the protein intakes of the shortest girls. The girls of average height tended to have intermediate values for their protein intakes.

The tallest girls had mean dietary protein values above the allowances from 6 through 12 years of age. The shortest girls had mean protein intakes that were less than the allowances most of the time. The girls of average height had mean values that were approximately equal to the allowances to 13 years, then the values were slightly below the allowances.

The mean daily protein intake was greater for the tallest children than for the shortest children. The

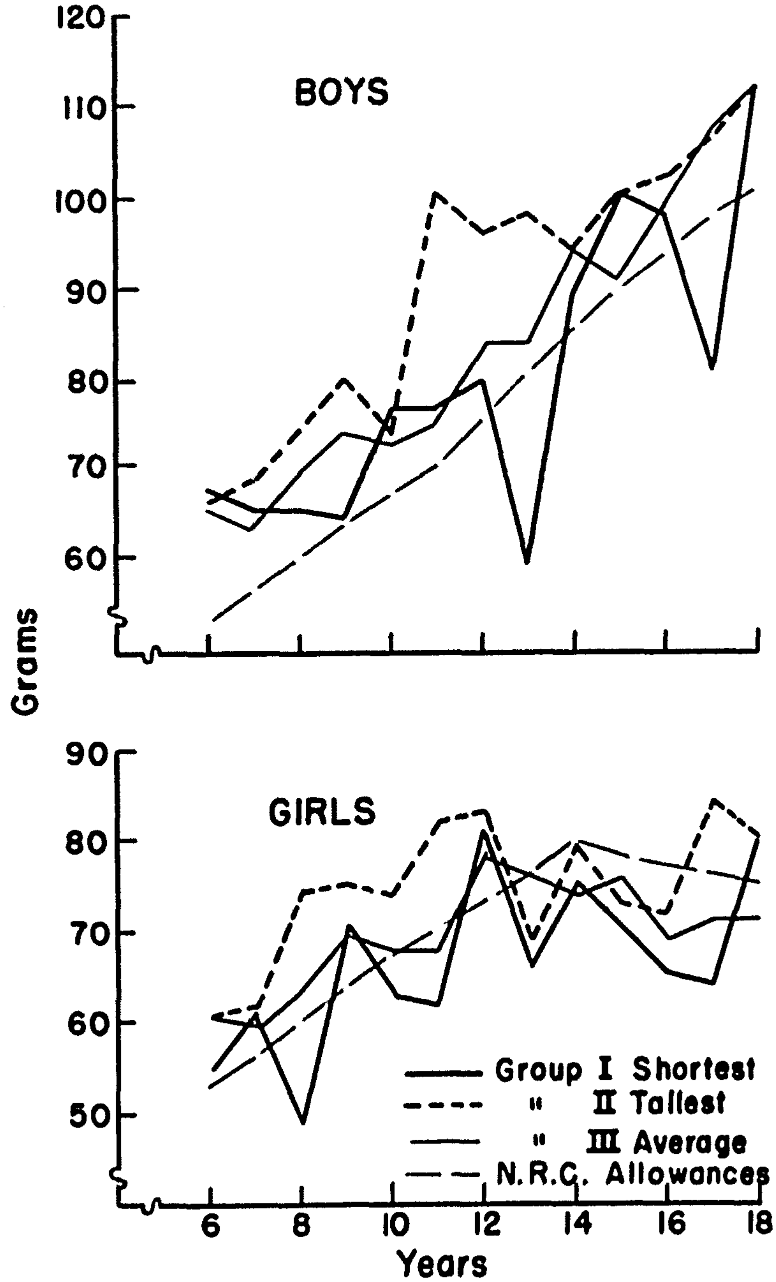

Fig. 14 Mean daily protein content of the diets of Iowa children classified according to three height groups.

children with average height tended to have protein intakes that were intermediate to the other two groups.

The mean daily calcium intake of the tallest boys was greater than the intakes of the shortest boys except at 6, 7, 10 and 15 years of age. The boys of average height had somewhat intermediate values for the calcium intakes. The tallest boys had calcium intakes equal to the allowances at many more ages than was noted for the shortest or average boys. The shortest boys had diets with calcium content that were below the allowances except at 6 and 7 years of age, and the boys of average height had diets with values below the allowances except from 6, 7, 8 and 17 years of age (see Figure 15).

The tallest girls had mean intakes of dietary calcium that exceeded those of the shortest girls except from 13 to 15 years of age. From 6 to 12 years of age the girls of average height had calcium intakes that were intermediate to the other two groups. With the girls below the teen ages, the mean calcium intakes varied in the same direction as the mean heights, but thereafter calcium intakes bore no consistent relationship to heights. The mean daily intakes of calcium were less than the allowances from the three height groups of girls except for the tallest 6- and 8-year-old girls and the 8-year-old girls of average height, but

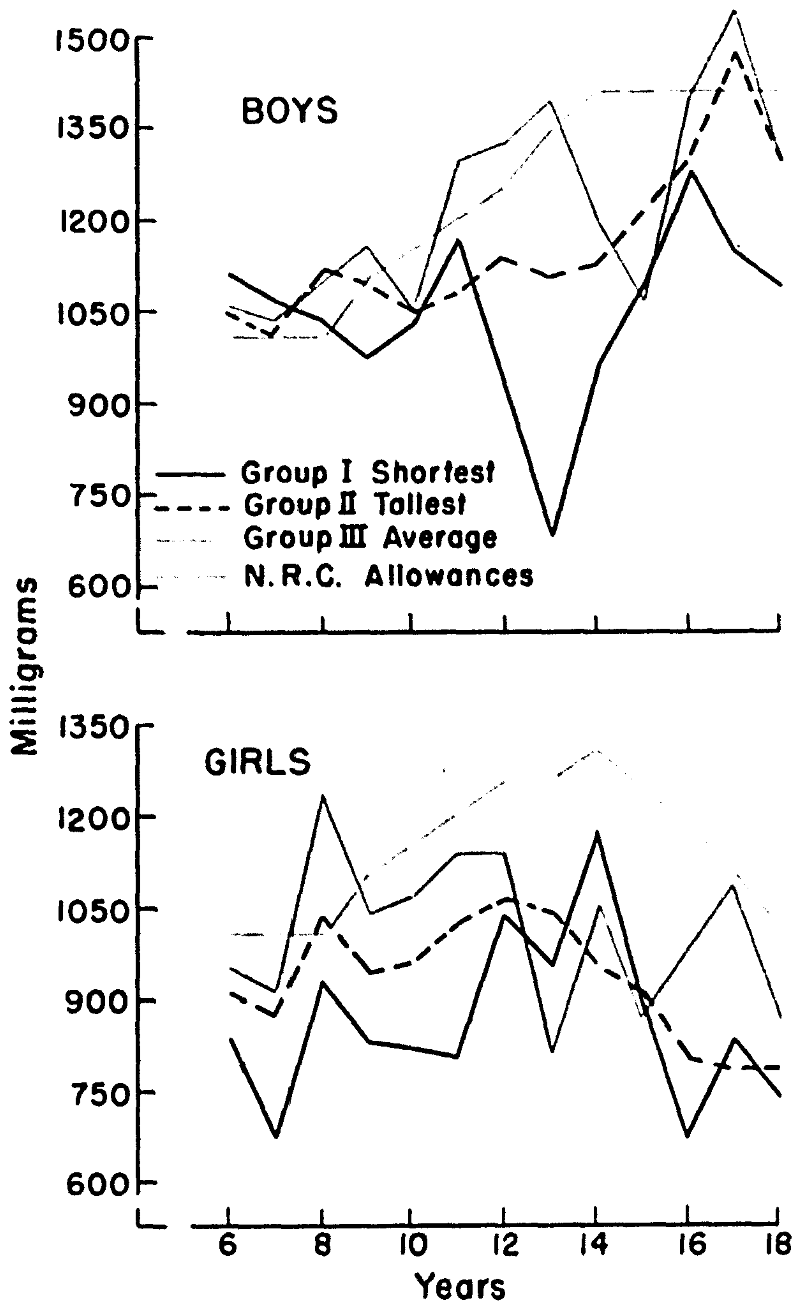

Fig. 15 Mean calcium content of diets of Iowa children classified according to three groups of heights

below the teens the girls had intakes that were less than the allowances.

The tallest boys had iron intakes that were most of the time greater than those of the shortest boys. The boys of average height had values often intermediate to the values of the other two groups. The iron intakes of the three groups of boys either exceeded or were equal to the allowances except for the shortest 13 and 14 year old boys.

The tallest girls usually had mean daily intakes of iron greater than those of the shortest girls, but when the average group is considered it cannot be said that the mean heights varied consistently in the direction of the mean daily iron intakes.

The tallest girls from 6 to 12 years of age, girls of average height from 6 to 10 years of age, and the shortest girls from 6 to 7, 9 th 10 and 18 years of age had diets with iron contents that approximated the allowances, otherwise the intakes of iron were below recommendations.

In general, the tallest boys and girls up to 13 years had mean daily iron intakes that were greater than those of the other two groups. With a few exceptions in the shortest group of boys, the mean iron intake of the three groups of boys were comparable to the allowances. With the exception of the 7- to 11-year-olds, the tallest girls had mean iron intakes that were below the allowances. The diets of the tallest boys usually had a higher mean ascorbic acid content than the diets of the shortest boys.

The mean daily ascorbic intake of the tallest boys was greater than the allowances except at 13, 14, 17 and 18 years of age. Regardless of height status boys seemed to have more ascorbic acid than suggested by the allowances. The negative deviations from the allowances were the greatest for the shortest teen-age boys.

The mean ascorbic acid content of the diets of the tallest girls was greater than that noted in the diets of the shortest girls at most ages. The girls of average height had mean dietary intakes of vitamin C that were either intermediate or above the values of the other two groups.

The diets of the three groups of girls from 6 to 12 years of age had mean daily ascorbic acid values in excess of or equal to the allowances. Afterwards only the girls of average height had diets with ascorbic acid contents continuously greater than the allowances.

The calculated mean daily thiamine intake of the tallest boys was nearly always above that of the shortest boys, while that of the boys of average height was usually between the values for the other two groups at corresponding ages.

The tallest boys had diets with thiamine content that were greater than the allowances except at 10 years of age. The shortest boys and the boys of average height had dietary intakes of thiamine that varied about the allowances.

The mean daily thiamine content of the diets of the tallest girls was greater than that of the shortest girls to 13 years, but afterwards it was about the same for all three groupings.

The tallest girls had mean thiamine intakes that were above the allowances to 13 years. The shortest girls and the girls with average height had intakes of thiamine that were most of the time below the allowances.

The three groups of boys, classified according to height, had diets with mean riboflavin content that was practically alike to 10 years of age; afterwards it diverged roughly in the same order as the height classification. The three groups had dietary intakes of riboflavin above the allowances except the shortest boys at 13 and 17 years of age.

The mean dietary intake of riboflavin by the girls in the three groups tended to follow the order of the height groupings. The tallest girls and the girls with average height had diets with riboflavin content that were above the allowances through 12 years. Afterward the intake values were nearly equal to or below the recommendations. The diets of the shortest girls were nearly always lacking in this vitamin when compared with the allowances.

The niacin content of the diets of the tallest boys was greater than that of the shortest boys most of the time. The boys of average height had dietary niacin values that were often between the values of the other two groups. With few exceptions, the mean daily niacin intakes were greater than the allowances regardless of the height status.

The dietary intakes of niacin by the tallest girls tended to be greater than that of the shortest girls. The girls of average height had intakes often intermediate in value. The niacin intakes for the three groups of girls exceeded or approximated the allowances to 12 years; afterwards the values for the diets of the three groups were below the recommendations with those of the shortest girls deviating the most from the allowances.

The tallest boys tended to have diets with food energy values and nutrient contents that were higher than those noted for the shortest boys throughout the school age. The diets of the boys of average height tended to have mean values for the various nutrients that were intermediate to the mean values for the other two groups, particularly between 6 and 14 years. With the exception of the calcium intake, the tallest boys and the boys with average height had intakes of the different nutrients that exceeded or approached the recommended allowances.

From 6 to 13 years of age the tallest girls had larger nutrient intakes than the shortest girls. In this age range the girls with average height had intake values that were intermediate to the values of the other two groups. For the girls below 13 years nutrient intakes of the diet varied in the same direction as the height classification.

Except for calcium, the tallest girls and the girls with average height from 6 through 12 years had mean daily intakes of the various nutrients that approximated the allowances. From 13 to 18 years the girls regardless of height classification had intakes of the different nutrients that were frequently below the allowances.

Concentrations of the various blood constituents. The increases in linear growth depend upon the increases in the length of skeleton as a whole. The cartilaginous cells in the growing ends of the bone are particularly sensitive to the lack of certain components in the blood needed for calcification.

The serum ascorbic acid concentrations of boys and girls in the three groups tended to decrease with age to low levels between the ages of 13 to 15 years (see Figure 16). The trend was particularly conspicuous in the data for the boys for whom the minimum was reached by 13 years for the tallest, 14 years for the average and 15 for the shortest. The age at which the greatest depression was noted differed with the height classification (see Table 38).

The low values for the shortest boys occurred at the same time that the serum alkaline phosphatase concentrations were at their peak. For the boys of average height the peak in alkaline phosphatase concentration occurred a year before this low ascorbic acid concentrations, and for the tallest boys it was two years before the minimum ascorbic acid concentration was reached.

For the girls the minimum serum ascorbic acid concentrations were reached at 13 years for the tallest girls and those of average height, but not until 16 years for the shortest girls. In case of the girls the serum alkaline phosphatase concentrations were less uniformly related to the serum ascorbic acid minima, although in each instance the peak preceeded the depression of serum ascorbic acid concentration. These concurrent changes in serum alkaline

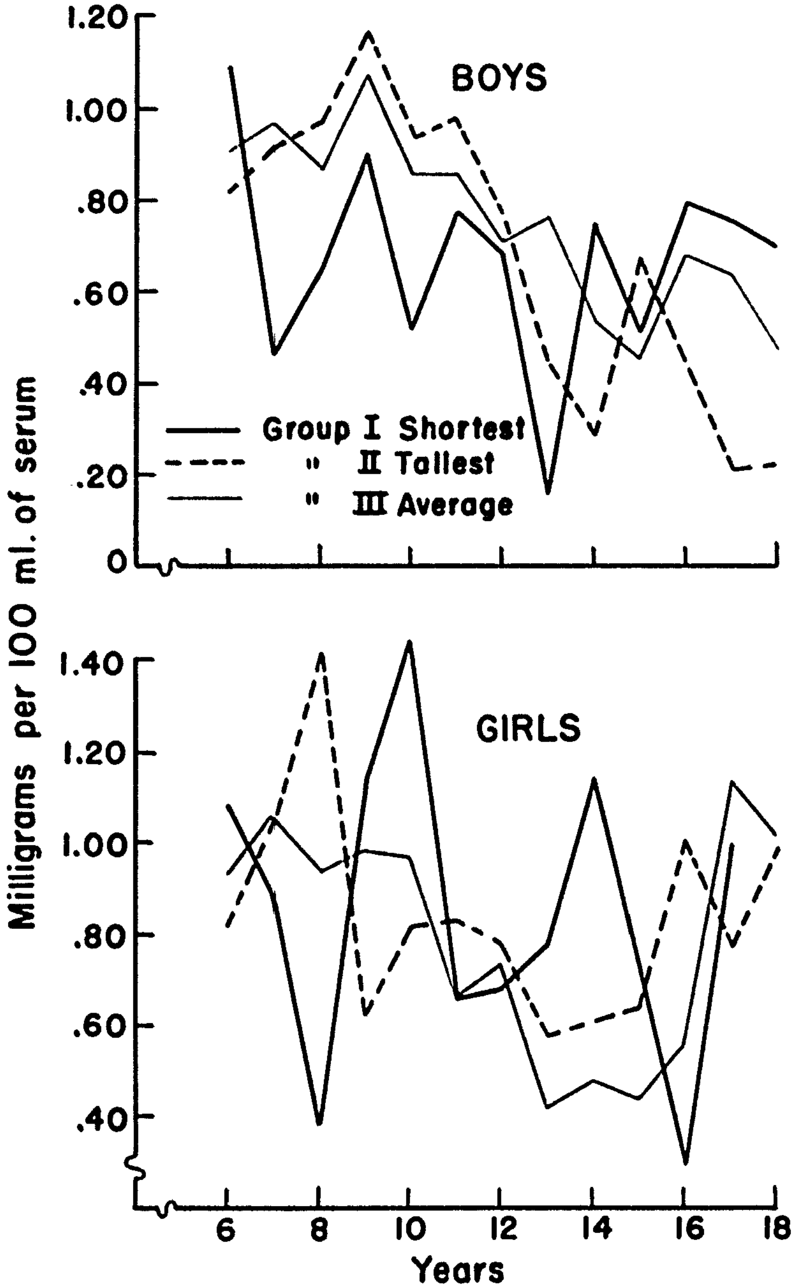

Fig.16 Mean serum ascorbic acid concentration of Iowa children classified according to three height groups

Table 38

Mean Serum Ascorbic Acid Concentrations of Iowa Children Classified According to Height Groups

Groups[a] Age yr.	I No.	I Mg.%	II No.	II Mg.%	III No.	III Mg.%
			Boys			
6	4	1.09	7	0.82	10	0.91
7	3	0.46	5	0.92	16	0.97
8	5	0.65	7	0.97	25	0.87
9	4	0.90	5	1.17	26	1.08
10	7	0.52	4	0.94	21	0.86
11	2	0.78	6	0.98	16	0.86
12	9	0.68	12	0.77	43	0.71
13	1	0.16	3	0.45	23	0.76
14	6	0.74	3	0.28	8	0.54
15	3	0.51	2	0.67	9	0.46
16	3	0.79	2	0.68	10	0.88
17	1	0.76	1	0.21	5	0.64
18	2	0.70	2	0.22	6	0.48
			Girls			
6	3	1.08	3	0.82	18	0.93
7	3	0.89	8	1.04	20	1.06
8	2	0.38	4	1.42	18	0.94
9	8	1.14	7	0.62	22	0.98
10	3	1.43	4	0.81	21	0.97
11	6	0.66	7	0.83	21	0.67
12	11	0.68	11	0.78	39	0.74
13	3	0.78	4	0.58	18	0.42
14	2	1.14	0	--	11	0.48
15	0	--	2	0.64	13	0.44
16	2	0.30	5	1.00	8	0.56
17	4	0.99	2	0.78	4	1.14
18	0	--	2	0.98	5	1.01

[a]Group I--Height minus 2 or 3 standard deviations
Group II--Height plus 2 or 3 standard deviations
Group III--Height within ± 1 standard deviations

phosphatase and serum ascorbic acid concentrations may reflect the rapid use of ascorbic acid in the process of bone growth.

The tallest boys to 13 years had serum ascorbic acid concentrations that were most of the time higher than those of the shortest boys. The serum ascorbic acid concentrations for the tallest girls and the shortest girls had values that fluctuated extensively. The boys and girls of average height had values that followed a more even trend from age to age than did the values of the groups at the two extremes of height.

The serum carotenoid concentrations for the three groups of boys and girls decreased with age, so a minimum was reached between 13 to 15 years (see Figure 17). The low concentrations were reached by the shortest boys at 13 years, the boys with average height and tallest boys at 15 years. According to these data the shortest girls did not have concentrations as conspicuously low as had the boys; however, data were lacking at 15 years (see Table 39). The tallest girls and those of average height reached a low level at 13 years of age. These low carotenoid concentrations for the boys and girls appeared in about the same age interim as the low ascorbic acid concentrations.

These low carotenoid and ascorbic acid concentrations occurred at the same time or within two years after the

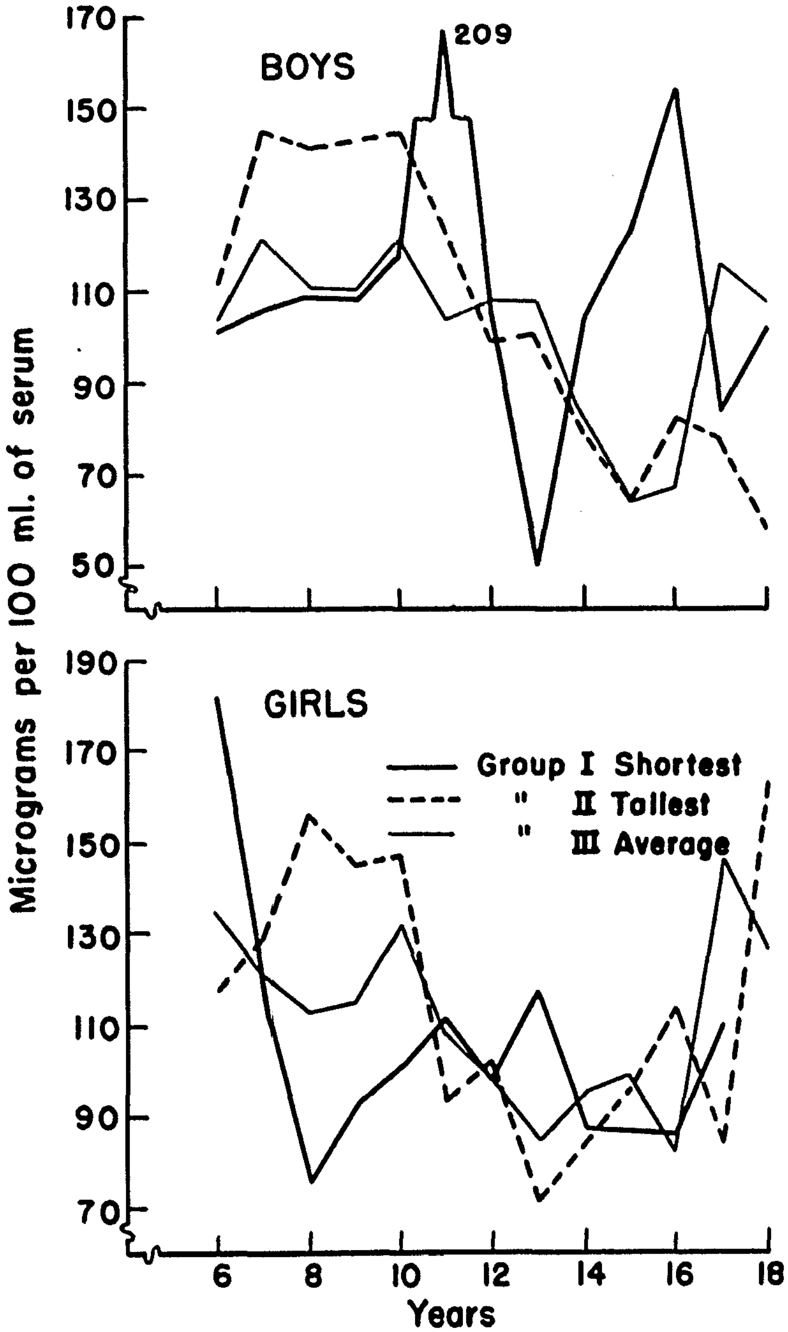

Fig.17 Mean serum carotenoid concentration of Iowa children classified according to three height groups

Table 39

Mean Serum Carotenoid Concentrations of Iowa Children Classified According to Height Groups

Groups[a]	I		II		III	
Age yr.	No.	Mcg.%	No.	Mcg.%	No.	Mcg.%
Boys						
6	3	101	7	112	11	103
7	3	106	6	145	16	121
8	5	109	6	141	23	111
9	4	108	4	108	23	110
10	7	118	5	144	22	121
11	2	209	6	122	18	104
12	10	106	12	98	43	107
13	1	50	3	100	22	107
14	6	104	3	79	8	81
15	2	122	2	64	9	64
16	2	154	2	82	9	67
17	1	84	1	78	5	116
18	2	102	2	57	6	108
Girls						
6	3	181	3	117	18	134
7	3	110	7	129	21	120
8	2	76	4	156	18	113
9	7	93	7	125	24	115
10	3	100	4	127	21	132
11	6	112	7	93	22	107
12	12	98	10	102	40	98
13	3	117	4	71	18	84
14	1	88	0	--	12	95
15	0	--	2	96	13	99
16	2	86	4	114	8	82
17	4	110	2	84	4	147
18	0	--	2	162	5	126

[a]Group I--Height minus 2 or 3 standard deviations
Group II--Height plus 2 or 3 standard deviations
Group III--Height within ± 1 standard deviations

peak in alkaline phosphatase concentrations. It appeared that not only serum ascorbic acid but also serum carotenoids may be utilized more rapidly by the body in spurts of linear growth than during the periods of slow linear growth.

The tallest and the shortest boys and the boys with average height started to show a decrease toward adult levels in concentrations of serum alkaline phosphatase at 12, 13 and 14 years, respectively. The tallest girls, the girls with average height and the shortest girls reached the peak at 10, 11 and 12 years, respectively (see Figure 18). With both sexes the tallest children attained the peaks of serum alkaline phosphatase before the other two groups (see Table 40). It was at these ages when the peaks were reached that the boys and the girls also made more than usual increment in linear growth.

There were few notable differences in the hemoglobin concentrations in the blood of the three height groups for boys and girls. The tallest boys perhaps tended to have higher values than the shortest boys, as shown by the higher concentrations in 8 out of 13 age groups (see Table 41).

Summary

1. The weights of the tallest boys tended to be the heaviest, and those of the shortest boys the lightest. The

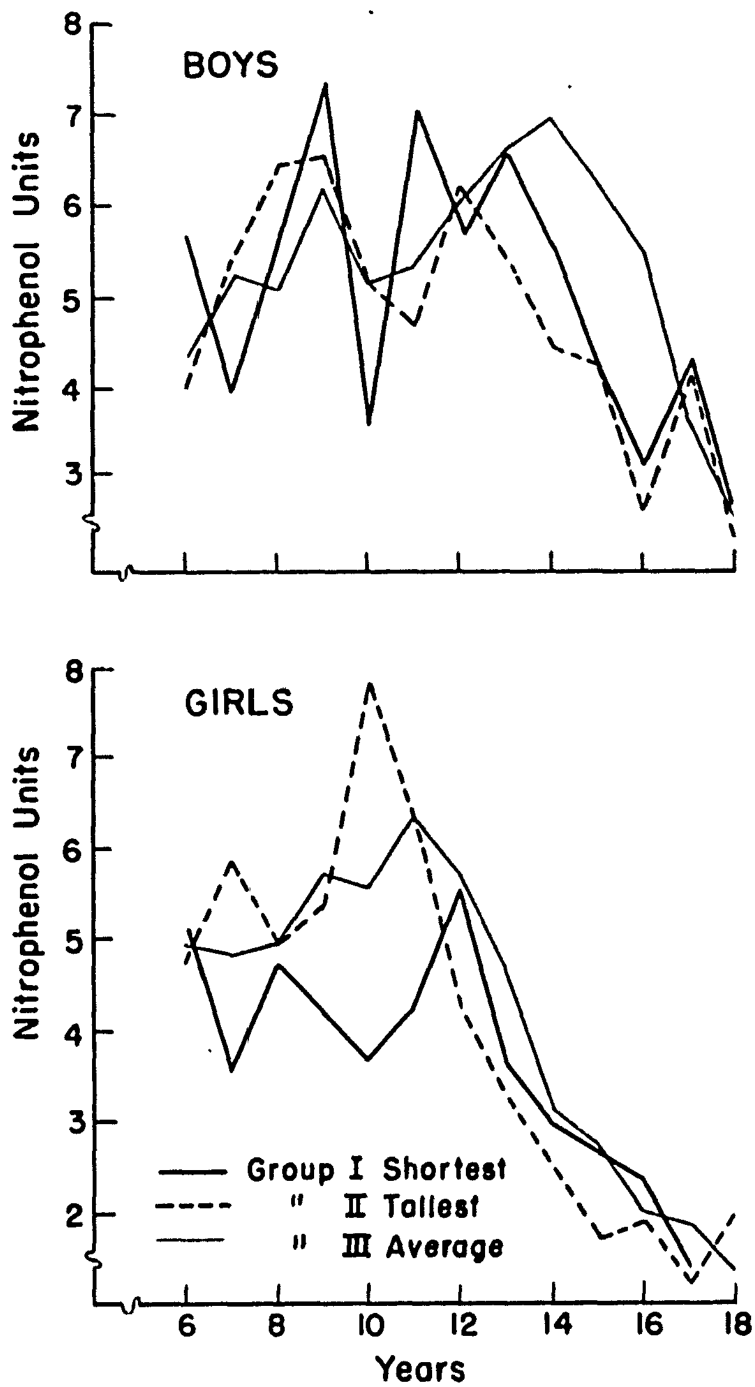

Fig. 18 Mean serum alkaline phosphatase concentrations of Iowa children classified according to three height groups

Table 40

Mean Serum Alkaline Phosphatase Concentrations of Iowa Children Classified According to Height Groups

Groups[a] Age yr.	I No.	I NP.U.[b]	II No.	II NP.U.[b]	III No.	III NP.U.[b]
			Boys			
6	4	5.64	7	4.00	11	4.32
7	2	3.94	6	5.40	20	5.21
8	5	5.58	7	6.41	25	5.04
9	4	7.35	4	6.50	27	6.14
10	7	3.63	5	5.14	23	5.13
11	2	7.00	6	4.69	16	5.32
12	10	5.69	12	6.20	43	6.09
13	1	6.61	4	5.41	21	6.60
14	6	5.54	3	4.46	8	6.93
15	3	4.19	2	4.26	9	6.24
16	3	3.13	2	2.68	10	5.48
17	1	4.30	1	4.06	5	3.62
18	2	2.48	2	2.08	6	2.54
			Girls			
6	4	5.08	3	4.75	20	4.97
7	3	3.56	8	5.89	21	4.84
8	2	4.77	4	4.95	18	4.95
9	8	4.18	7	5.37	24	5.71
10	3	3.70	4	7.76	22	5.58
11	6	4.29	7	6.27	20	6.37
12	12	5.52	11	4.23	41	5.71
13	3	3.68	4	3.28	18	4.63
14	2	2.98	0	--	12	3.13
15	0	--	2	1.74	13	2.78
16	2	2.38	5	1.91	8	2.01
17	4	1.42	2	1.21	4	1.90
18	0	--	2	2.00	5	1.35

[a]Group I Height minus 2 or 3 standard deviations
Group II Height plus 2 or 3 standard deviations
Group III Height within ± 1 standard deviation

[b]Nitrophenol units.

Table 41

Mean Hemoglobin Concentration in Blood of Iowa Children Classified According to Height Groups

Groups[a]	I		II		III	
Age yr.	No.	Gm.%	No.	Gm.%	No.	Gm.%
			Boys			
6	6	12.1	10	12.1	20	12.0
7	9	11.9	12	12.7	35	12.2
8	6	12.6	10	12.8	35	13.0
9	4	12.2	7	13.0	41	13.1
10	10	12.8	8	12.3	43	13.0
11	7	12.4	7	13.2	34	12.6
12	14	12.7	14	13.4	58	13.2
13	3	12.3	6	13.2	33	13.4
14	8	13.0	6	14.6	27	13.2
15	5	14.7	5	14.9	22	14.1
16	5	14.3	5	14.0	24	14.4
17	3	14.4	2	14.4	16	14.3
18	4	15.3	4	14.2	10	14.9
			Girls			
6	7	12.3	6	12.7	35	12.3
7	6	12.1	10	13.0	31	12.2
8	5	13.3	6	12.8	27	11.9
9	9	12.7	10	12.9	40	12.6
10	8	12.7	7	12.6	44	12.6
11	9	12.1	6	13.0	42	13.2
12	12	13.7	13	13.2	53	13.5
13	5	12.2	7	13.2	32	13.1
14	4	13.3	6	13.0	27	12.9
15	5	13.1	6	12.1	27	12.7
16	4	13.4	5	13.0	27	13.0
17	4	12.6	4	13.4	17	13.1
18	1	14.3	3	12.6	8	12.4

[a]Group I--Height minus 2 or 3 standard deviations
Group II--Height plus 2 or 3 standard deviations
Group III--Height within ± 1 standard deviations

boys of average height had weights intermediate to the other two groups. The weight of the shortest teen-age girls tended to be heavy for their height.

2. The tallest boys had nutrient intakes that were higher than those of the shortest boys at nearly all ages. The boys of average height tended to have mean intake values at each age that were more often than not intermediate to the values of the other two groups.

3. For the tallest girls below 12 or 13 years of age the mean intakes of dietary nutrients were greater than those of the shortest girls at most ages. After 12 or 13 years, there was no apparent relationship between height status and dietary intake as shown by group means.

4. The tallest boys and the boys of average height tended to have nutrient values that either exceeded or closely approached the suggested values in the allowances, except for calcium. The shortest boys had nutrient intakes that were below the allowances more frequently than was observed for either of the other two groups.

5. To 12 or 13 years the tallest girls and the girls of average height tended to have intakes that approached or exceeded the allowances except for calcium. Afterwards the mean daily intakes by all the girls regardless of height status tended to be less than the allowances.

6. The serum concentrations of ascorbic acid and carotenoids tended to decrease with age for three height groups of boys and girls so the minima were reached between 13 and 16 years.

7. These lowest concentrations in serum ascorbic acid and carotenoids usually occurred within one or two years after the peak concentration in the serum alkaline phosphatase.

8. The peaks in serum alkaline phosphatase concentrations occurred at 12 years for the tallest, at 13 years for the shortest boys and at 14 years for the boys of average height.

9. The peaks in serum phosphatase concentrations appeared at 10 years for the tallest girls, at 11 years for the girls of average height and at 12 years for the shortest girls.

10. The tallest boys from 8 to 13 years tended to have higher hemoglobin concentrations in the blood than had the other two groups of boys.

Developmental Levels of Iowa Children

Height and weight are measurements of two kinds of growth. According to Krogman (1950) Wetzel has devised a method of using these two measurements along with age to estimate the rate of development, the physique and the rate of growth of a child. This chart is known as the Wetzel Grid.

The Grid has two halves, a right and a left. "On the right side of the graph is a channel system sloping upward from left to right. These channels are crossed at regular intervals of ten units by more or less horizontal 'iso-developmental level lines' which are, in effect, increment units." Each channel establishes the body build. From the extreme left to the right the channels typify the following physical status and physique, obese, stocky, good, fair, borderline and poor. The channel fulfills two purposes: 1. it describes the child's body build; 2. it shows paths of growth from 6 to 18 years.

This left side of the Grid points out growth in height, in weight, and in development as measured by the levels. Body build is indicated by the channel. Nutritional grade is measured "by the slope of the child's own curve (normal if it parallels a channel, overnutrition if the slope is greater than the channel system, undernutrition if it is less)". Physical status is determined by a combination of the four factors just mentioned.

<u>Mean developmental level of a total sample of Iowa children</u>

The most effective use of the Grid is obtained through a series of observations on a single child over a period of time. But the Grid may be used to describe a group of children on whom only a single measurement has been made. One height and one weight measurement was made on these Iowa children in the present study; therefore, developmental level and physique or body build only at the time of measurement can be noted. The measurements were plotted on the Grid to obtain an estimate of the developmental level, which may be considered a crude estimate of the surface area.

Wetzel (1941) claimed that a child developing at a normal rate should advance ten developmental levels a year. The boys showed the largest mean increment in developmental levels between the ages of 12 and 13 years, and between the ages of 14 and 15 years; the girls showed the largest increment between the ages of 8 to 9, 9 to 10, and 10 to 11 years (see Table 42). The boys increased nearly twice the amount and the girls one and one-half times the amount estimated by Wetzel. The range in developmental level at each age-sex group was extensive, especially at 12 years for both the girls and the boys.

Table 42

Mean Developmental Levels[a] of Iowa Children

Age yr.	No.	Mean D.L.[a]	Standard deviation D.L.[a]	Standard error D.L.[a]	Range D.L.
			Boys		
6	38	53.1	12.7	2.1	28 - 84
7	58	64.2	13.4	1.8	29 - 112
8	53	78.4	16.4	2.3	50 - 116
9	55	90.2	17.1	2.3	54 - 125
10	60	96.1	12.8	1.6	69 - 134
11	50	107.2	19.6	2.8	68 - 158
12	90	114.9	20.1	2.1	68 - 170
13	44	132.9	18.3	2.8	80 - 168
14	40	139.6	20.8	3.3	101 - 180
15	32	160.0	11.6	2.0	131 - 186
16	34	162.6	15.2	2.6	131 - 210
17	21	163.4	16.7	3.6	128 - 210
18	18	166.6	14.7	3.5	141 - 191
			Girls		
6	50	50.2	15.7	2.2	20 - 90
7	48	63.8	17.8	2.6	32 - 118
8	44	69.2	15.9	2.4	41 - 117
9	64	84.9	20.2	2.5	41 - 127
10	61	99.4	20.8	2.7	57 - 150
11	58	114.6	14.6	1.9	71 - 150
12	82	125.6	23.3	2.6	82 - 195
13	44	129.4	19.8	3.0	78 - 163
14	37	140.2	13.8	2.3	111 - 166
15	38	149.9	13.9	2.3	120 - 174
16	37	150.8	14.6	2.4	126 - 196
17	26	151.5	14.7	2.9	125 - 187
18	12	146.6	8.6	2.5	128 - 159

[a]As obtained from Wetzel Grid.

<u>Study of the children with the lowest developmental level, highest developmental level and average developmental level</u>

In order to segregate the children who had developed more rapidly or less rapidly from those children developing at average rate according to the Grid, each age-sex group was divided into three different groups. Group I was comprised of all the children who had developmental levels within second or third standard deviations below the mean; Group II, of all the children who had developmental levels within second or third standard deviations above the mean; Group III, of all the children who had developmental levels within plus or minus one standard deviation of the mean.

In the total population 14 per cent of the boys and 16 per cent of the girls were in the highest developmental level; 12 per cent of the boys and 14 per cent of the girls, in the lowest developmental level; and 74 per cent of the boys and 70 per cent of the girls, in the average developmental level.

In the discussion these three new groups will be referred to as follows: Group I, lowest developmental level; Group II, highest developmental level; and Group III, average developmental level.

Nutrient intake. Recently Spies (1953) reported that children who had symptoms of nutritional failure showed a lag in developmental level. The lag could be overcome to a large degree if a supplement of milk solids equal to one quart of fresh milk was given to each child six days per week for 20 months. Milk solids equal to two quarts per day induced a larger improvement, but a pint a day for a longer period of time, 40 months, resulted in very little improvement. This study by Spies indicated that developmental level does reflect nutritional status and dietary treatment. In Tables 43 and 44 are presented the mean dietary intakes of the children classified according to the three developmental levels.

The boys in the highest developmental level had food energy values that were nearly always greater than those of the boys with the lowest developmental level. The boys in the average developmental levels had diets with caloric values that were intermediate to the other two groups (see Figure 19).

The boys from 6 to 15 years of age of the highest developmental level had diets with mean food energy values that either exceeded or approximated the allowances. The boys of average developmental level had diets with food energy values that followed the allowances closely.

Table 43

**Mean Daily Food Energy and Nutrient Content of Diets of
Children Classified According to Three Developmental Lev**

Boys

Age in yrs.	No.	Groups[a]	D.L.[a]	Age in mos.	Food energy cal.	Protein gm.	Calcium mg.	Iron mg.	Ascor aci mg
6	5	I	33.0	76	1923	63	966	9	8
	7	II	72.4	80	2419	74	1143	11	9
	25	III	52.0	78	2196	66	1057	9	7
7	7	I	43.7	88	2041	61	931	9	6
	6	II	76.4	92	2298	72	1044	10	8
	43	III	63.8	89	2168	65	1039	10	7
8	2	I	53.0	100	1750	58	1060	7	7
	8	II	100.5	99	2261	70	1034	11	11
	44	III	72.6	99	2295	72	1099	10	7
9	8	I	64.2	111	2307	70	1047	11	7
	8	II	118.0	116	2461	76	1148	11	8
	37	III	91.7	114	2454	74	1090	11	8
10	7	I	76.8	124	2649	81	996	12	8
	6	II	122.5	129	2484	77	1158	12	9
	47	III	95.9	125	2374	72	936	11	7
11	5	I	77.6	136	2642	62	1128	11	8
	9	II	140.0	138	2857	95	1273	13	9
	36	III	104.2	137	2551	78	1092	11	8

[a]Group	Developmental Levels
I	Minus 2 or 3 standard deviations
II	Plus 2 or 3 standard deviations
III	Within ± 1 standard deviation

Table 43

Daily Food Energy and Nutrient Content of Diets of Iowa
ren Classified According to Three Developmental Level Groups

Boys

ge n os.	Food energy cal.	Protein gm.	Calcium mg.	Iron mg.	Ascorbic acid mg.	Thiamine mg.	Ribo-flavin mg.	Niacin mg.
76	1923	63	966	9	80	0.9	1.7	10
80	2419	74	1143	11	93	1.2	2.0	12
78	2196	66	1057	9	77	1.1	1.9	11
88	2041	61	931	9	65	0.9	1.7	11
92	2298	72	1044	10	84	1.1	2.0	12
89	2168	65	1039	10	72	1.0	1.8	11
100	1750	58	1060	7	78	0.9	1.8	8
99	2261	70	1034	11	116	1.2	1.9	12
99	2295	72	1099	10	71	1.1	2.1	10
111	2307	70	1047	11	78	1.1	2.0	12
116	2461	76	1148	11	83	1.2	2.0	13
114	2454	74	1090	11	85	1.2	2.1	13
124	2649	81	996	12	81	1.3	1.9	17
129	2484	77	1158	12	92	1.2	2.1	13
125	2374	72	936	11	74	1.1	2.0	13
136	2642	62	1128	11	82	1.2	2.0	12
138	2857	95	1273	13	95	1.4	2.3	16
137	2551	78	1092	11	84	1.2	2.0	13

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Table 43 (continued)

Age in yrs.	No.	Groups[a]	D.L.[a]	Age in mos.	Food energy cal.	Protein gm.	Calcium mg.	Iron mg.	Ascorbic acid mg.
12	13	I	86.7	148	2501	78	893	12	62
	13	II	139.1	151	3034	95	1266	14	104
	64	III	113.6	148	2729	84	1154	13	85
13	6	I	106.5	159	2518	75	897	12	77
	6	II	162.0	162	3024	93	1270	14	75
	32	III	131.5	161	2916	88	1160	14	105
14	4	I	104.2	172	2881	83	926	14	71
	6	II	171.6	173	3263	99	1023	16	61
	29	III	138.7	174	3080	90	1158	14	100
15	4	I	141.3	183	3282	97	1103	18	105
	4	II	178.0	185	3256	98	1232	15	113
	24	III	160.0	186	3212	92	1179	15	93
16	3	I	133.3	197	3042	85	1160	13	89
	4	II	189.0	196	3030	94	1338	13	111
	24	III	162.1	196	3534	102	1329	16	113
17	2	I	137.0	212	2129	81	1144	10	96
	2	II	197.0	210	2898	90	1046	13	62
	17	III	163.9	209	3607	109	1444	17	107
18	1	I	141.0	234	3240	80	891	14	50
	4	II	188.5	224	3513	101	1410	15	110
	12	III	161.7	221	3431	105	1129	16	81

Age in mos.	Food energy cal.	Protein gm.	Calcium mg.	Iron mg.	Ascorbic acid mg.	Thiamine mg.	Ribo-flavin mg.	Niacin mg.
148	2501	78	893	12	62	1.2	1.8	14
151	3034	95	1266	14	104	1.4	2.5	16
148	2729	84	1154	13	85	1.3	2.2	15
159	2518	75	897	12	77	1.1	1.8	13
162	3024	93	1270	14	75	1.4	2.3	15
161	2916	88	1160	14	105	1.4	2.2	16
172	2881	83	926	14	71	1.3	1.7	16
173	3263	99	1023	16	61	1.5	2.3	18
174	3080	90	1158	14	100	1.5	2.3	16
183	3282	97	1103	18	105	1.5	2.3	20
185	3256	98	1232	15	113	1.6	2.8	18
186	3212	92	1179	15	93	1.5	2.5	16
197	3042	85	1160	13	89	1.5	2.1	13
196	3030	94	1338	13	111	1.4	2.5	15
196	3534	102	1329	16	113	1.7	2.5	18
212	2129	81	1144	10	96	1.1	2.0	13
210	2898	90	1046	13	62	1.3	2.1	14
209	3607	109	1444	17	107	1.7	2.8	18
234	3240	80	891	14	50	1.4	1.9	22
224	3513	101	1410	15	110	1.9	2.9	18
221	3431	105	1129	16	81	1.7	2.5	18

Table 44

**Mean Daily Food Energy and Nutrient Content of Diets of [illegible]
Children Classified According to Three Developmental Lev[illegible]**

Girls

Age in yrs.	No.	Groups[a]	D.L.[a]	Age in mos.	Food energy cal.	Protein gm.	Calcium mg.	Iron mg.	Ascor[illegible] aci[illegible] mg
6	7	I	26.4	77.8	1705	54	806	8	66
	7	II	75.3	78.1	1952	66	1171	9	86
	36	III	50.0	78.1	2012	61	896	9	62
7	5	I	40.6	87.4	1940	54	771	8	81
	6	II	100.0	91.3	1997	66	1048	10	104
	37	III	61.7	89.3	1992	61	864	9	7[illegible]
8	7	I	47.6	101.4	1744	53	809	8	6[illegible]
	5	II	100.0	102.2	2138	68	1152	10	9[illegible]
	31	III	69.1	100.4	2070	64	1030	9	7[illegible]
9	9	I	54.7	112.8	2433	73	957	11	81
	11	II	117.9	114.4	2299	72	953	11	7[illegible]
	42	III	83.1	114.0	2245	68	964	10	8[illegible]
10	7	I	69.7	123.0	2140	63	831	10	8[illegible]
	11	II	134.2	127.5	2370	72	1009	12	10[illegible]
	43	III	95.3	125.4	2293	68	939	11	8[illegible]
11	9	I	87.9	136.1	1898	60	868	9	8[illegible]
	14	II	138.2	137.6	2296	70	1046	10	7[illegible]
	35	III	109.6	137.3	2341	71	1032	10	8[illegible]

[a]Group	Developmental Levels
I	Minus 2 or 3 standard deviations
II	Plus 2 or 3 standard deviations
III	Within ± 1 standard deviation

Table 44

ly Food Energy and Nutrient Content of Diets of Iowa
Classified According to Three Developmental Level Groups

Girls

	Food energy cal.	Protein gm.	Calcium mg.	Iron mg.	Ascorbic acid mg.	Thiamine mg.	Ribo-flavin mg.	Niacin mg.
.8	1705	54	806	8	66	0.9	1.4	9
.1	1952	66	1171	9	86	1.0	2.1	10
.1	2012	61	896	9	62	1.0	1.6	10
.4	1940	54	771	8	81	0.9	1.6	10
.3	1997	66	1048	10	104	1.1	1.8	10
.3	1992	61	864	9	73	1.0	1.6	10
.4	1744	53	809	8	67	0.9	1.5	9
.2	2138	68	1152	10	90	1.0	2.2	11
.4	2070	64	1030	9	75	1.0	1.8	10
.8	2433	73	957	11	81	1.1	1.9	13
.4	2299	72	953	11	76	1.1	1.9	12
.0	2245	68	964	10	82	1.1	1.8	12
.0	2140	63	831	10	82	1.0	1.7	11
.5	2370	72	1009	12	100	1.2	2.0	13
.4	2293	68	939	11	84	1.1	1.8	12
.1	1898	60	868	9	85	1.0	1.6	11
.6	2296	70	1046	10	76	1.1	1.9	12
.3	2341	71	1032	10	80	1.1	1.9	12

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Table 44 (continued)

Age in yrs.	No.	Groups[a]	D.L.[a]	Age in mos.	Food energy cal.	Protein gm.	Calcium mg.	Iron mg.	Ascorbic acid mg.
12	14	I	92.3	147.8	2740	83	1096	13	73
	10	II	166.7	148.9	2298	74	1040	11	95
	57	III	127.0	148.9	2586	80	1067	12	82
13	6	I	91.1	158.2	2268	71	918	11	70
	6	II	156.5	160.7	2772	84	1287	12	78
	32	III	131.5	161.1	2453	72	954	11	76
14	6	I	120.8	172.8	2492	75	1046	12	66
	6	II	160.2	171.3	2394	69	916	12	94
	25	III	140.0	173.1	2507	76	990	12	83
15	5	I	128.0	183.2	2698	84	1040	13	104
	9	II	168.6	185.7	2588	72	787	12	81
	24	III	147.4	186.2	2578	74	912	12	87
16	6	I	132.5	194.3	2651	76	928	12	220
	6	II	175.8	196.8	2118	70	790	10	77
	24	III	148.8	198.1	2276	67	787	11	86
17	4	I	132.7	208.8	2188	66	794	11	74
	5	II	175.8	208.8	2068	63	795	10	82
	16	III	149.1	209.1	2536	77	868	12	90
18	2	I	132.0	222.0	2551	84	1068	11	75
	1	II	159.0	228.0	2665	68	742	11	68
	9	III	149.1	221.8	2446	72	748	12	99

Age in mos.	Food energy cal.	Protein gm.	Calcium mg.	Iron mg.	Ascorbic acid mg.	Thiamine mg.	Ribo-flavin mg.	Niacin mg.
147.8	2740	83	1096	13	73	1.3	2.1	14
148.9	2298	74	1040	11	95	1.1	1.9	13
148.9	2586	80	1067	12	82	1.2	2.0	14
158.2	2268	71	918	11	70	1.1	2.3	12
160.7	2772	84	1287	12	78	1.2	2.3	13
161.1	2453	72	954	11	76	1.1	1.7	13
172.8	2492	75	1046	12	66	1.1	1.9	13
171.3	2394	69	916	12	94	1.1	1.9	13
173.1	2507	76	990	12	83	1.2	2.0	13
183.2	2698	84	1040	13	104	1.3	2.0	15
185.7	2588	72	787	12	81	1.1	1.7	14
186.2	2578	74	912	12	87	1.2	1.8	14
194.3	2651	76	928	12	220	1.3	1.9	13
196.8	2118	70	790	10	77	1.1	1.6	12
198.1	2276	67	787	11	86	1.1	1.6	12
208.8	2188	66	794	11	74	1.1	1.8	11
208.8	2068	63	795	10	82	1.0	1.4	10
209.1	2536	77	868	12	90	1.2	1.7	14
222.0	2551	84	1068	11	75	1.3	2.0	14
228.0	2665	68	742	11	68	1.1	1.5	14
221.8	2446	72	748	12	99	1.2	1.5	14

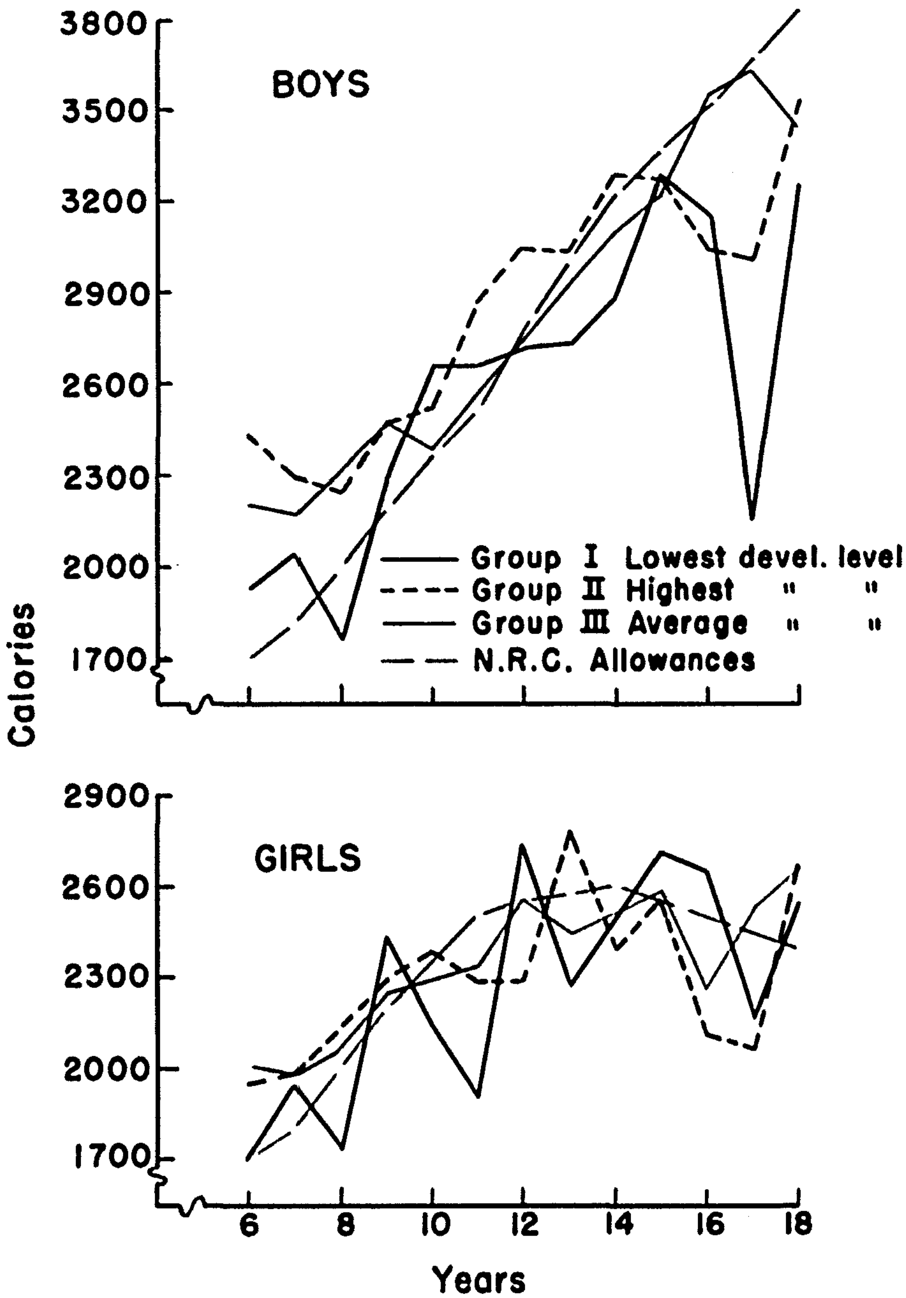

Fig.19 Mean daily food energy value of the diets of Iowa children classified according to three developmental levels

The caloric values of the diets of the boys in the lowest developmental level were less than the allowances at 7 of 13 age groups.

The girls of the highest developmental level from 6 to 13 years tended to have higher caloric intakes than did the girls in the lowest developmental level. After 13 years, the girls with the lowest developmental level had higher caloric intakes than did the girls in the highest developmental level. The girls with the average developmental level had diets with food energy values that were more or less intermediate to the values of the other two groups.

From 6 to 10 years of age the girls in highest and in the average developmental level had diets with food energy values that were above the allowances. After 10 years the girls in the average group had mean daily caloric intakes that followed the recommendations more closely than did those of the girls with highest developmental level. The girls in the lowest developmental level had intakes that were as often above as below the allowances. Below 12 years there was some evidence that the mean caloric intakes did follow the same classification as the mean developmental level of the girls, but above 12 years there was no consistent relationship between mean food energy values and developmental levels.

From 6 to 12 years the boys and the girls with the highest developmental level had diets with a protein content that was greater than those observed for the lowest developmental level at the same age. The boys of the highest developmental level continued to have greater protein intakes than those of the lowest developmental level, but after 14 years the girls with the highest developmental levels had intakes of protein lower than those of the girls with the lowest developmental level (see Figure 20). For the boys under 15 years and the girls under 12 years the protein intakes tended to follow the direction of the developmental level.

The boys with average developmental levels had mean daily protein intakes which exceeded the allowances. The girls with average developmental level had mean daily intakes which approximated the allowances within plus or minus five grams except at 16 years. At that age the girls with average developmental level had mean daily intakes of about ten grams less than the allowances. The boys, except the 17 year olds, and the girls to 13 years with the highest developmental level had mean protein intakes that were greater than or nearly like the allowances. The boys and the girls with the lowest developmental level had mean dietary intakes of protein that were below, as often as

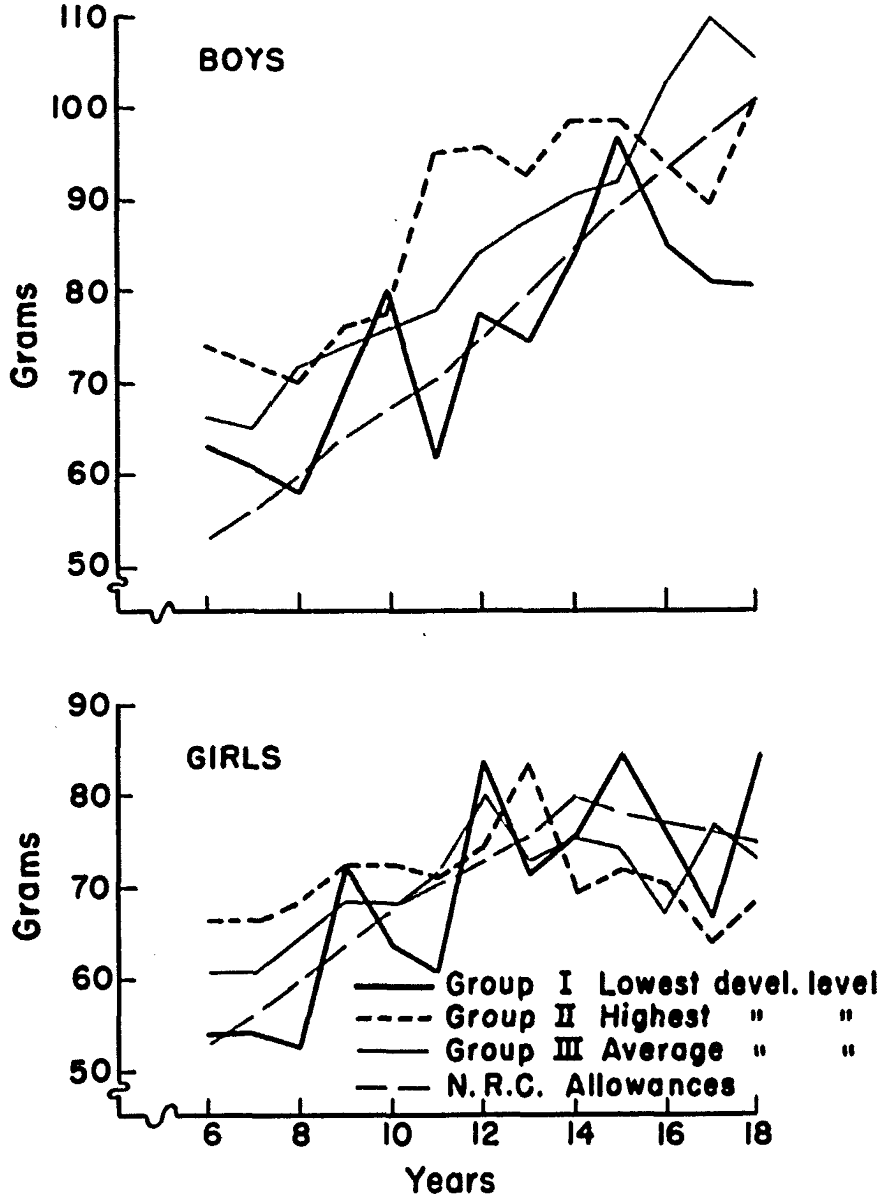

Fig. 20 Mean daily protein content of diets of Iowa children classified according to three developmental levels

above, the allowances. Of the three groups those of the lowest developmental level most often had diets with protein contents in amounts less than the allowances.

The calcium content of the diets of the boys with the highest developmental level was in general greater than the intakes of the boys in the lowest developmental level. The boys with average developmental levels had diets with calcium contents that varied between the calcium values of the other two groups. The boys with highest developmental levels had diets with calcium content greater than the recommendations from 6 to 12 years of age (see Figure 21). In fact boys of the highest developmental level had mean daily calcium intakes which conformed with the allowances to within 100 milligrams except at 14, 15 and 17 years. The boys of the lowest developmental levels had diets with calcium content that were below the allowances throughout the age range except at the 8 year, when the mean daily intake of calcium barely met the allowances. Beyond 11 years of age the deviation from the allowances ranged from 350 to 500 milligrams. The boys above nine years in the average developmental level had diets below the allowances but the deviations were much less than those noted for the boys of the lowest developmental level.

For girls 6 to 12 the mean calcium intake of the children varied in the same direction as the developmental

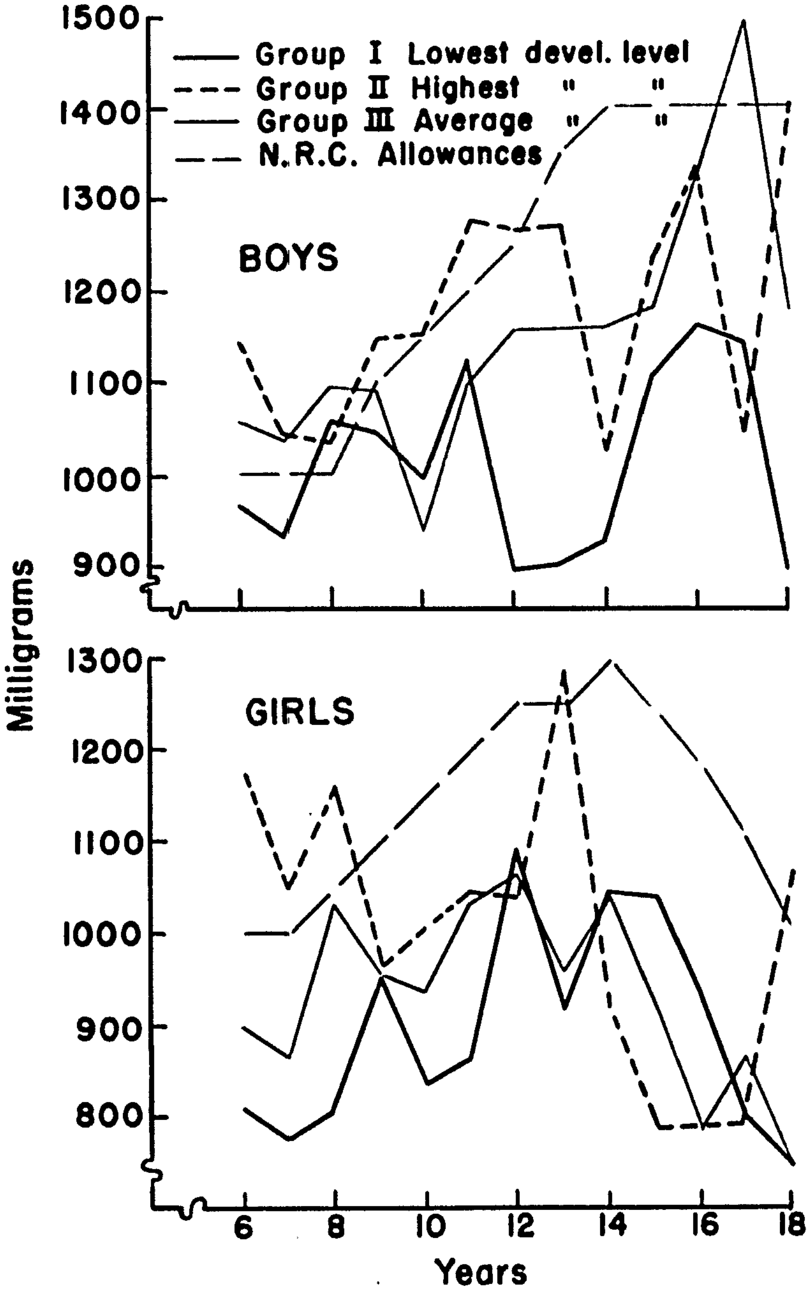

Fig. 21 Mean daily calcium content of diets of Iowa children classified according to three developmental levels

level. The girls with the highest developmental levels from 6 to 14 years tended to have the largest mean daily intakes of calcium; the girls with the lowest developmental levels, the smallest calcium intakes; and the girls with average developmental level, intakes that were intermediate to those of the other two groups. From 14 to 18 years, there was no consistent relationship between developmental level and calcium intakes. In the "teen-ages" the girls with the highest developmental levels tended to have the lowest calcium intake and girls with the lowest developmental level the largest mean daily intake of calcium. The dietary intakes of calcium for the three groups of girls were less than the allowances except for the 6-, 7-, 8-, 13- and 18-year-old girls in the highest developmental level, and the 8-year-olds in the average developmental level.

From 6 to 14 years the boys of the highest developmental level had diets richer in iron than those of the lowest developmental level. The iron content of the diets of the boys in the three groups roughly followed the classification of the developmental levels. The iron intakes of the boys of the highest and of average developmental levels were about equivalent to the allowances, whereas in 8 of the 13 age groups the iron intakes of the boys of the lowest developmental levels were considerably less than the allowances.

From 6 through 13 years the girls of highest developmental level tended to have daily intakes of iron which exceeded those of the lowest developmental level. In this age range the girls of average developmental level had iron intakes almost identical with the allowances. In the teens there was no apparent relationship between developmental levels and mean daily iron intakes. Throughout the age range girls of lowest developmental level deviated most from the allowances with respect to iron intakes.

The boys from 6 to 12 years with the highest developmental level had a larger calculated mean ascorbic acid content in their diets than was noted for the other two groups. The boys in the average developmental level group had mean daily ascorbic acid intakes that were intermediate between the values of the other two groups (see Figure 22).

The boys with average developmental levels had ascorbic acid intakes that were greater than the allowances at all ages except at 18 years.

The boys in the highest developmental level failed to meet the allowances at 13, 14 and 17 years, whereas the boys in the lowest developmental level failed at 12, 13, 14, 16, 17, and 18 years.

From 6 to 12 years of age the girls with the highest developmental level tended to have ascorbic acid intakes that

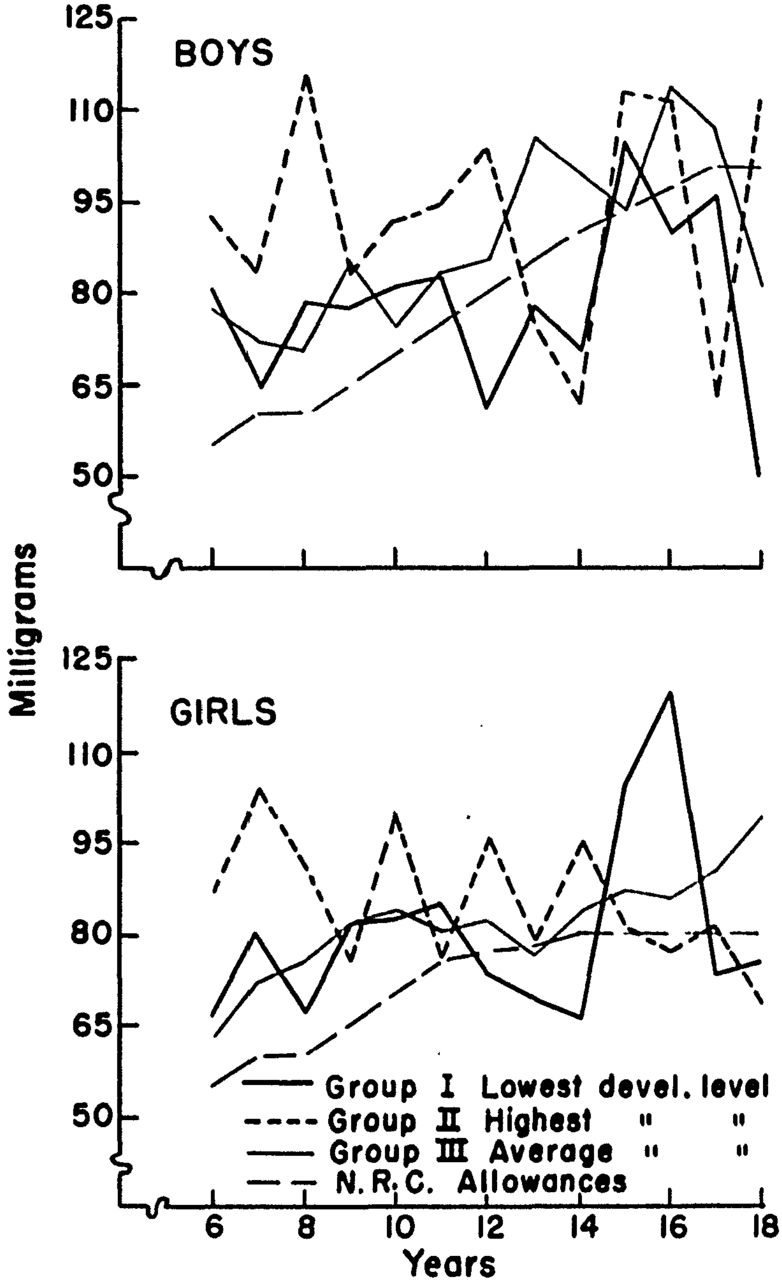

Fig. 22 Mean daily ascorbic acid content of diets of Iowa children classified according to three developmental levels

were greater than those of the other two groups. With few exceptions the girls in the three groups had intakes greater than the allowances.

The boys in the three developmental groups had mean daily thiamine intakes that followed closely the classification of the developmental levels from 6 to 16 years. The boys of the average and highest developmental level had diets that approximated the allowances. The boys with the lowest developmental level had diets with thiamine content less than allowances most of the time (see Figure 23).

The girls with the highest developmental level tended to have higher dietary thiamine intakes than did the girls in the lowest level from 6 to 11 years. After 12 years thiamine values of the diets of the girls in the highest developmental level tended to be lower than the thiamine values of the other two groups. From 6 to 12 years the girls with highest and the average developmental levels had mean daily intakes of thiamine that were equal to or greater than the allowances, afterwards the girls of all developmental levels tended to have less thiamine than recommended. The thiamine content of the diets of the girls with the lowest developmental level was below the allowances most of the time.

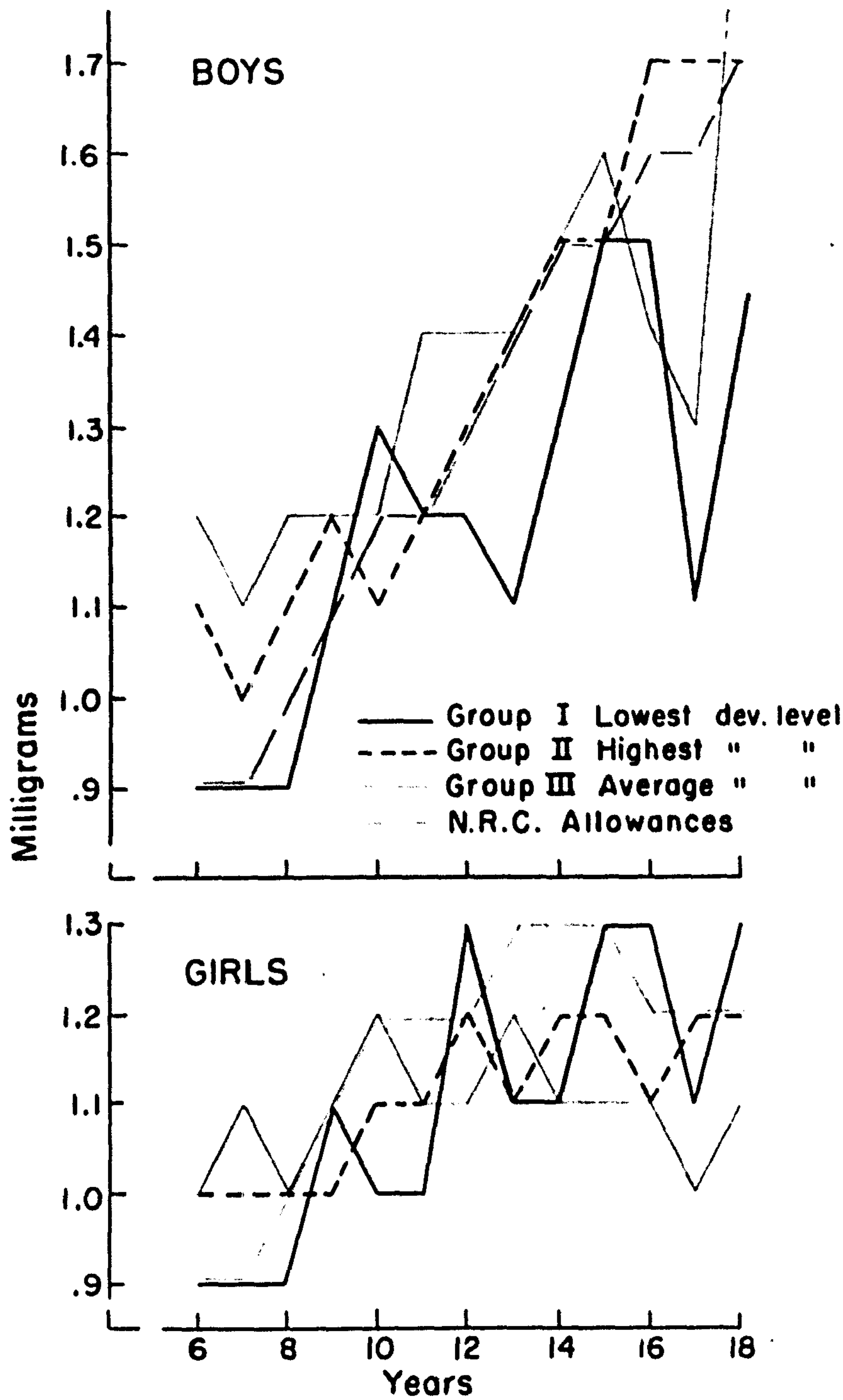

Fig. 23 Mean thiamine content of diets of Iowa children classified according to three groups of developmental level

The boys with the highest developmental level had diets with riboflavin content that was greater than that of the boys with the lowest levels. From 6 to 16 years the boys of average developmental level had mean daily intakes of riboflavin that were usually intermediate between the intakes of two groups. The diets of the boys with the highest and the average developmental levels had riboflavin intakes that almost always surpassed the allowances. From 6 to 11 years of age the boys with the lowest developmental level had intakes above the allowances, but afterward this group of boys tended to have less riboflavin than the allowances (see Figure 24).

The girls with the highest developmental level tended to have higher intakes of dietary riboflavin than the girls with the lowest level to 14 years, then the trend was reversed. The riboflavin intakes of all three groups approximated the allowances. The divergence was greatest for the teen-age girls of the highest and average developmental level who tended to have less riboflavin than the allowances.

The boys in the three groups had dietary niacin intakes that tended to parallel the developmental status at 6, 7, 8, 11 and 12 years. The mean daily niacin intakes of these boys were above the allowances most of the time.

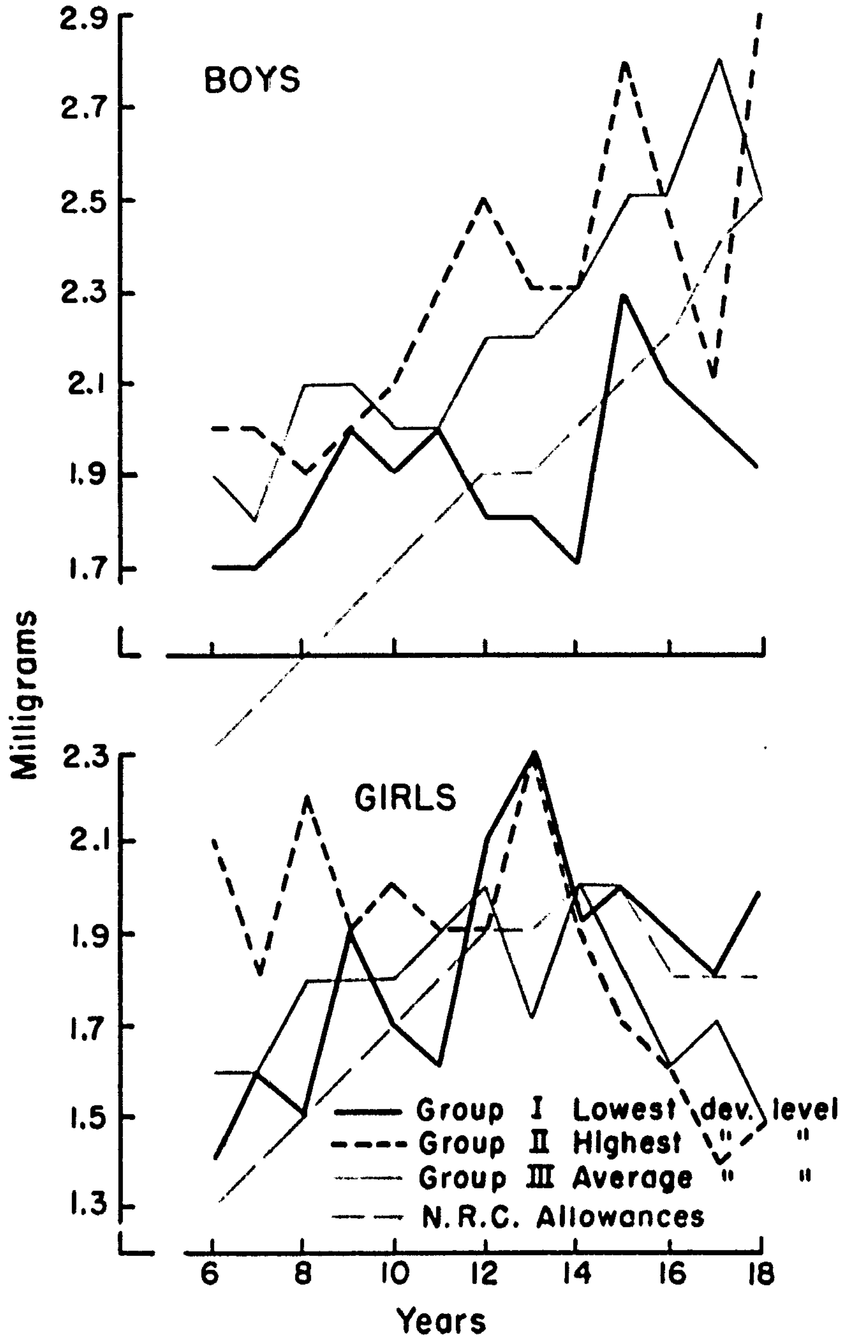

Fig. 24 Mean riboflavin content of diets of Iowa children classified according to three groups of developmental level

At a few ages the boys of the lowest developmental level had mean daily niacin intakes that were inclined to be below the allowances more often than had for the other two groups.

The values for the dietary niacin intake for the three groups of girls fluctuated extensively. The mean daily niacin intakes of the girls of the highest or average developmental level exceeded or were equal to the allowances, but the girls with the lowest developmental levels had mean daily intakes of niacin which were below the allowances at a number of ages.

The nutrient intakes either exceeded or equalled the allowances more frequently for the girls and boys of the highest and average developmental level than for the boys and girls of the lowest developmental level. The ages of the children in the highest and average developmental levels at which the intakes most frequently failed to meet the allowances were in the teens.

Concentration of the various blood constituents. At the highest developmental levels the serum ascorbic acid concentration of boys decreased from 1.0 milligram per cent at six years to 0.5 at 14 years; at the average developmental level the concentration decreased from 0.8 to 0.5 milligram per cent at 15 years; and at the lowest developmental level the concentration decreased from 1.1 to 0.3 milligram at 13 years (see Figure 25). The low concentrations reached at each developmental level cannot be accounted for by the calculated mean ascorbic acid intakes which were 61 milligrams, 93 milligrams and 77 milligrams for the three groups at 14, 15 and 18 years, respectively. According to Young and her co-workers (1950) these intakes may be 25 per cent higher than the actual intake due to cooking and storage losses. Even with this correction the intakes do not explain fully the low concentrations, especially for the boys of average and of lowest developmental levels (see Table 45).

At most ages in all three groups the calculated mean intake of ascorbic acid approximated the allowances, yet the boys had low serum ascorbic acid concentrations. From these data it appeared that the ascorbic acid intakes nearly equal to the allowances did not supply the needs of boys through the stress of growth. Storvick and her associates (1950) in a comprehensive study noted that intakes of ascorbic acid equal to the allowances did not produce tissue saturation in growing children.

The girls with the highest and with the average developmental levels had serum ascorbic acid concentrations that ranged from nearly 1.0 milligram at 6 years to 0.4 and 0.5 milligram per cent, respectively, at 13 years. The calculated

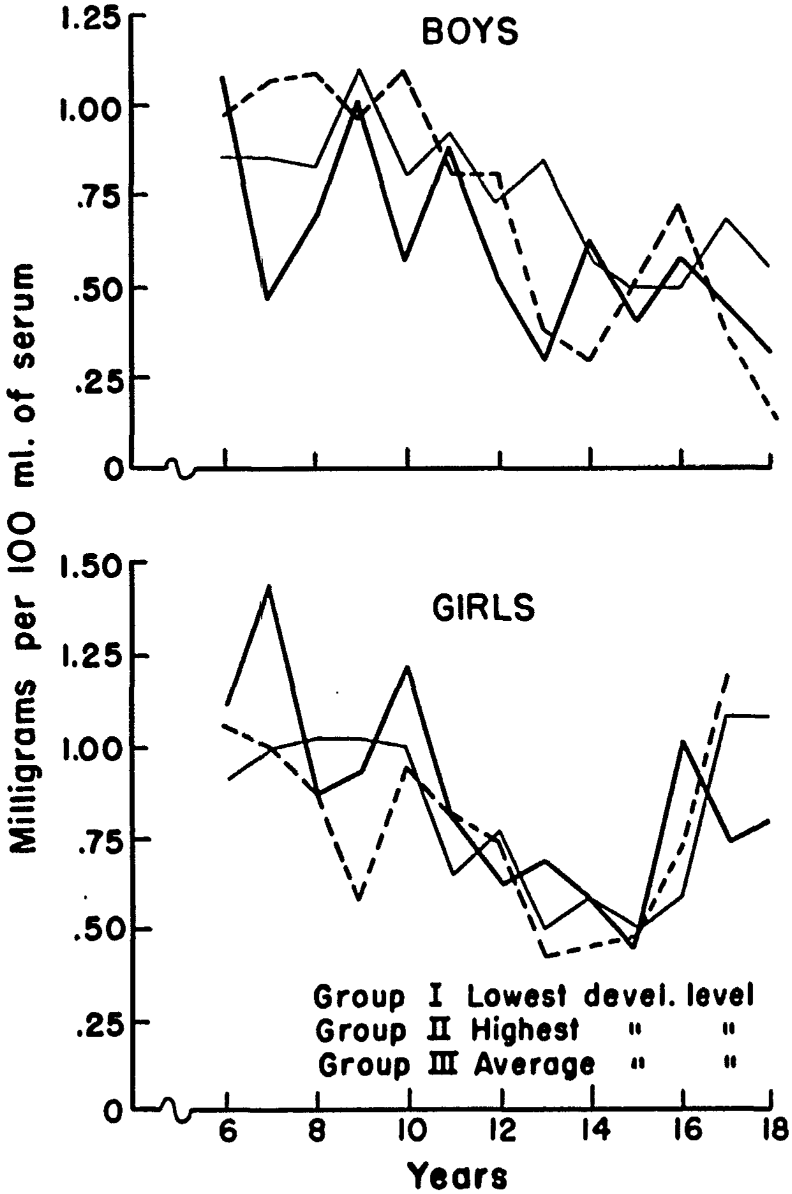

Fig. 25 Mean serum ascorbic acid concentration of Iowa children classified according to three developmental levels

Table 45

Mean Serum Ascorbic Acid Concentrations of Iowa Children Classified According to Developmental Levels[b]

Groups[a]	I		II		III	
Age yr.	No.	Mg.%	No.	Mg.%	No.	Mg.%
			Boys			
6	3	1.08	5	0.91	13	0.85
7	3	0.46	3	1.07	20	0.85
8	2	0.69	6	1.10	29	0.82
9	6	1.02	6	0.98	23	1.11
10	3	0.56	3	1.08	26	0.79
11	3	0.90	6	0.81	15	0.91
12	8	0.54	11	0.81	45	0.72
13	2	0.29	5	0.38	20	0.83
14	3	0.63	2	0.30	12	0.58
15	1	0.40	1	0.52	12	0.50
16	2	0.60	3	0.73	10	0.50
17	0	--	2	0.36	5	0.69
18	1	0.31	1	0.13	8	0.54
			Girls			
6	3	1.08	4	1.05	17	0.90
7	4	1.44	4	0.99	23	0.99
8	4	0.87	5	0.91	15	1.02
9	9	0.93	4	0.56	24	1.02
10	2	1.23	4	0.93	22	0.99
11	3	0.79	10	0.81	21	0.64
12	11	0.62	7	0.74	43	0.77
13	2	0.68	2	0.42	21	0.48
14	1	0.58	0	--	12	0.58
15	4	0.44	3	0.47	8	0.48
16	2	1.00	4	0.73	9	0.58
17	3	0.74	2	1.20	5	1.09
18	2	0.80	0	--	5	1.09

[a]Group	Developmental levels from Wetzel's Grid
I	Minus 2 or 3 standard deviations
II	Plus 2 or 3 standard deviations
III	Within ± standard deviations

[b]Developmental levels from Wetzel's Grid.

mean ascorbic acid contents of the diets of these girls were equal to the allowances. The girls with the lowest developmental levels had concentrations of serum ascorbic acid that decreased from nearly 1.1 milligram per cent at 6 years to 0.4 milligram per cent at 14 years. The mean calculated ascorbic acid intakes for the girls in the highest developmental level was 78 milligrams; for the girls in the average group, 75 milligrams; and for the girls in the lowest group, 66 milligrams. As with the boys again mean intakes equal to the allowances did not provide growing girls with amounts of vitamin C adequate to maintain a high serum concentration at all ages.

The serum concentrations of ascorbic acid at 13 and 14 years were lower than can be accounted for on the basis of food intake. These results suggest that regardless of developmental level classification, the serum ascorbic acid concentration is reduced under the stress of growth or body changes at puberty.

The boys and girls in the highest developmental level had mean serum carotenoid concentrations that decreased markedly from 6 to 15 and 13 years, respectively (see Figure 26). Boys had a mean carotenoid concentration of 117 micrograms per 100 milliliters of serum at 6 years, of 44 micrograms at 15 years. The girls at six years had a mean concentration of 184 micrograns, and at 13 years mean concentrations of 46 micrograms.

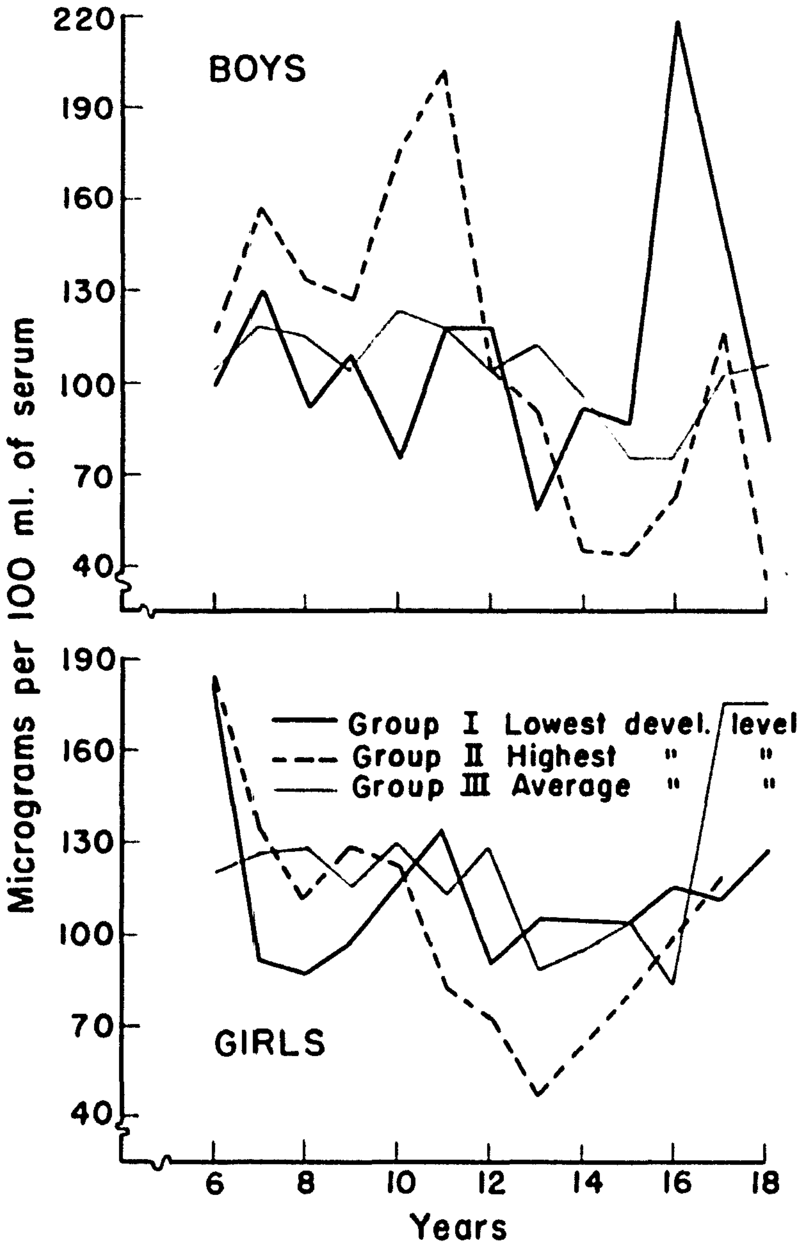

Fig. 26 Mean serum carotenoid concentration of Iowa children classified according to three developmental levels

The boys and girls in the other two developmental level groups had mean serum carotenoid concentrations that decreased from 6 years to the interim of 12 to 15 years (see Table 46). The decrease was not as dramatic for these groups of boys and girls as it was for the children in the highest developmental level. The especially low concentrations in all groups of boys and girls cannot be explained by the intakes of these children, for the mean daily vitamin A value of their diets either exceeded or approximated the allowances at each age.

Since the disappearance of carotenes in the blood may be associated with the conversion to vitamin A, the precipitous decrease noted in the serum carotenoid concentrations of the children in the highest developmental level, and to a lesser degree in the concentrations of the children of the average developmental level, may suggest a greater use of vitamin A by more rapidly developing children than by the slowly developing children.

Before the boys of the highest and the lowest developmental levels reached the peak in their mean serum alkaline phosphatase concentrations, the values fluctuated greatly (see Figure 27). The boys in the average developmental level had less fluctuation from year to year than had the other two groups. The boys in the average and the lowest

Table 46

Mean Serum Carotenoid Concentrations of Iowa Children Classified According to Developmental Levels[b]

Groups[a]	I		II		III	
Age yr.	No.	Mcg.%	No.	Mcg.%	No.	Mcg.%
			Boys			
6	4	98	5	117	12	104
7	4	130	3	156	18	118
8	2	92	5	133	27	115
9	5	108	6	127	20	105
10	3	74	3	176	28	124
11	2	118	6	201	18	117
12	9	118	10	103	46	104
13	2	58	5	91	19	112
14	3	92	2	46	12	95
15	1	86	1	44	11	74
16	1	218	3	62	9	74
17	--	--	2	116	5	102
18	1	81	1	33	8	106
			Girls			
6	3	181	4	184	17	120
7	4	91	4	134	23	126
8	4	87	5	110	15	128
9	8	97	5	128	25	115
10	2	116	4	122	22	130
11	3	135	10	82	22	112
12	12	90	6	72	44	128
13	2	105	2	46	21	88
14	--	--	--	--	13	95
15	4	103	3	81	8	103
16	2	115	4	99	8	83
17	3	108	2	119	5	175
18	2	127	--	--	5	176

[a]Group	Developmental levels from Wetzel's Grid
I	Minus 2 or 3 standard deviations
II	Plus 2 or 3 standard deviations
III	Within ± 1 standard deviations

[b]Developmental levels from Wetzel's Grid.

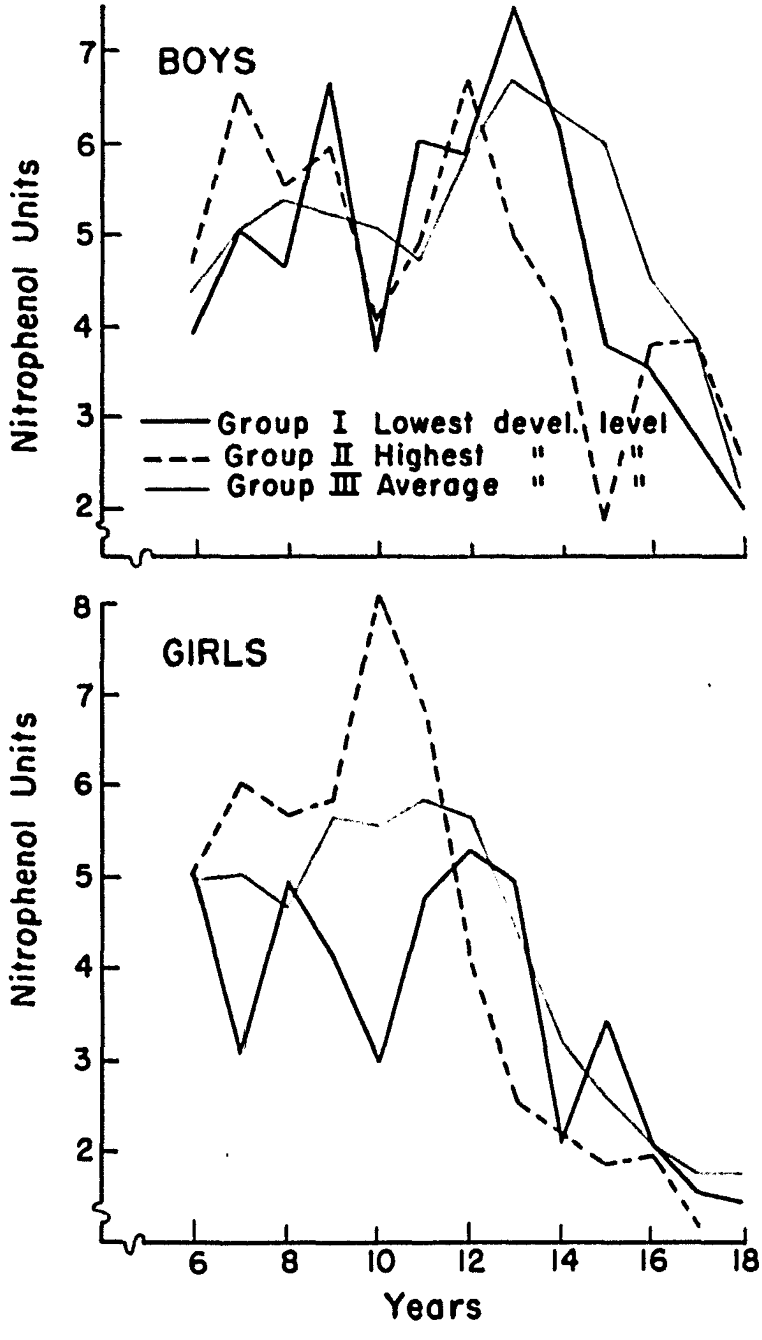

Fig. 27 Mean serum alkaline phosphatase concentration of Iowa children classified according to three developmental levels

developmental levels had mean serum concentrations that reached the peak at 13 years of age, as compared with 12 years for the boys with the highest developmental level (see Table 47).

The serum alkaline phosphatase concentrations of the girls followed the same classification as the developmental levels to 10 years. The age at which the peak was reached varied with developmental level. The girls of the highest developmental level had mean serum concentrations that attained the peak value at 10 years and the girls of the lowest developmental level had mean concentrations that attained the peak value at 12 years. The girls of average developmental level did not have concentrations that reached a sharp definite peak but the highest mean value appeared at 11 years.

In both sexes the children with the highest developmental level reached maturity at an earlier age than the other two groups of children, as shown by the serum alkaline phosphatase concentration.

The boys in lowest developmental level had hemoglobin concentrations that tended to be lower than did those of the boys in the highest developmental level (see Table 48).

From 6 to 12 years the girls of average developmental level tended to have mean hemoglobin concentrations below

Table 47

Mean Serum Alkaline Phosphatase Concentrations of Iowa Children Classified According to Developmental Level[b]

Groups[a]	I		II		III	
Age yr.	No.	NP.U.[c]	No.	NP.U.	No.	NP.U.
		Boys				
6	4	3.90	5	4.38	13	4.66
7	3	5.02	3	6.50	22	5.00
8	2	4.64	6	5.53	29	5.38
9	6	6.65	6	6.91	23	5.21
10	3	3.73	3	3.94	29	5.04
11	3	6.03	6	4.88	17	4.70
12	9	5.89	11	6.68	45	5.93
13	2	7.47	5	4.97	19	6.69
14	3	6.15	2	4.16	12	6.28
15	1	3.78	1	1.89	12	5.96
16	2	3.53	3	3.78	10	4.48
17	--	--	2	3.81	5	3.76
18	1	1.96	1	2.19	8	2.53
		Girls				
6	4	5.08	4	5.09	19	4.97
7	4	3.03	4	6.05	24	5.04
8	4	4.94	5	5.70	15	4.69
9	9	4.18	5	5.81	25	5.60
10	2	2.95	4	8.04	23	5.55
11	3	4.77	9	6.81	21	5.84
12	12	5.30	7	4.12	45	5.65
13	2	4.98	2	2.53	21	4.41
14	1	2.10	0	--	13	3.19
15	4	3.42	3	1.82	8	2.56
16	2	2.05	4	1.94	9	2.06
17	3	1.56	2	1.15	5	1.75
18	2	1.47	0	--	5	1.76

[a]Group	Developmental levels from Wetzel's Grid
I	Minus 2 or 3 standard deviations
II	Plus 2 or 3 standard deviations
III	Within ± 1 standard deviation

[b]Developmental level from Wetzel's Grid.

[c]Nitrophenol units.

Table 48

Mean Hemoglobin Concentrations of Iowa Children Classified According to Developmental Levels[b]

Groups[a]	I		II		III	
Age yr.	No.	Gm.%	No.	Gm.%	No.	Gm.%
			Boys			
6	5	11.7	6	11.8	25	12.2
7	7	12.0	5	13.1	44	12.2
8	2	12.0	8	12.4	41	13.0
9	7	12.7	8	13.3	37	13.0
10	7	12.4	6	12.3	48	13.0
11	5	13.0	8	13.1	35	12.5
12	13	12.6	13	13.5	60	13.2
13	6	12.6	6	13.0	30	13.5
14	4	13.1	6	13.7	31	13.3
15	4	13.8	4	15.0	24	14.3
16	3	14.1	4	14.2	27	14.4
17	2	13.4	2	14.9	17	14.2
18	1	13.8	4	14.8	13	14.9
			Girls			
6	7	12.4	7	12.6	34	12.3
7	5	12.4	6	12.6	36	12.3
8	6	11.8	5	12.4	27	12.1
9	9	12.6	10	12.7	40	12.6
10	7	12.7	10	12.9	42	12.5
11	9	12.5	13	13.3	35	12.9
12	13	13.6	9	13.1	56	13.5
13	6	12.4	6	12.5	32	12.8
14	6	12.5	6	12.6	25	13.1
15	5	12.7	9	13.1	24	12.8
16	6	12.5	6	13.1	24	13.2
17	4	13.4	5	12.5	16	13.2
18	2	12.1	1	12.5	9	12.7

[a]Group	Developmental level from Wetzel's Grid
I	Minus 2 or 3 standard deviations
II	Plus 2 or 3 standard deviations
III	Within 2 or 3 standard deviations

[b]Developmental levels from Wetzel's Grid.

those of the girls of the highest developmental level, and comparable with those of the girls with the lowest developmental level. After 12 years the hemoglobin concentrations of the girls with average developmental level tended to be the highest. The decrease of the mean concentrations of the girls with highest developmental levels may be a reflection of the poor intakes in calories, iron and protein.

Comparison of the three groups of boys and girls by means of the regression

The main objective in this phase of the study was to quantify the differences among the groups of boys and girls classified according to the developmental level. The data were classified into three groups, each of which was a composite of the children irrespective of age; that is, all boys in the lowest developmental level for each age from 6 to 18 years made up Group I in this section of the study. All boys of the highest developmental level formed Group II, and those of the average developmental level, Group III. Regression coefficients were calculated for developmental level (y) on mean daily intake of some of the nutrients and mean concentrations of blood constituent for each of the three groups in both sexes. Results are shown in Tables 49 and 50.

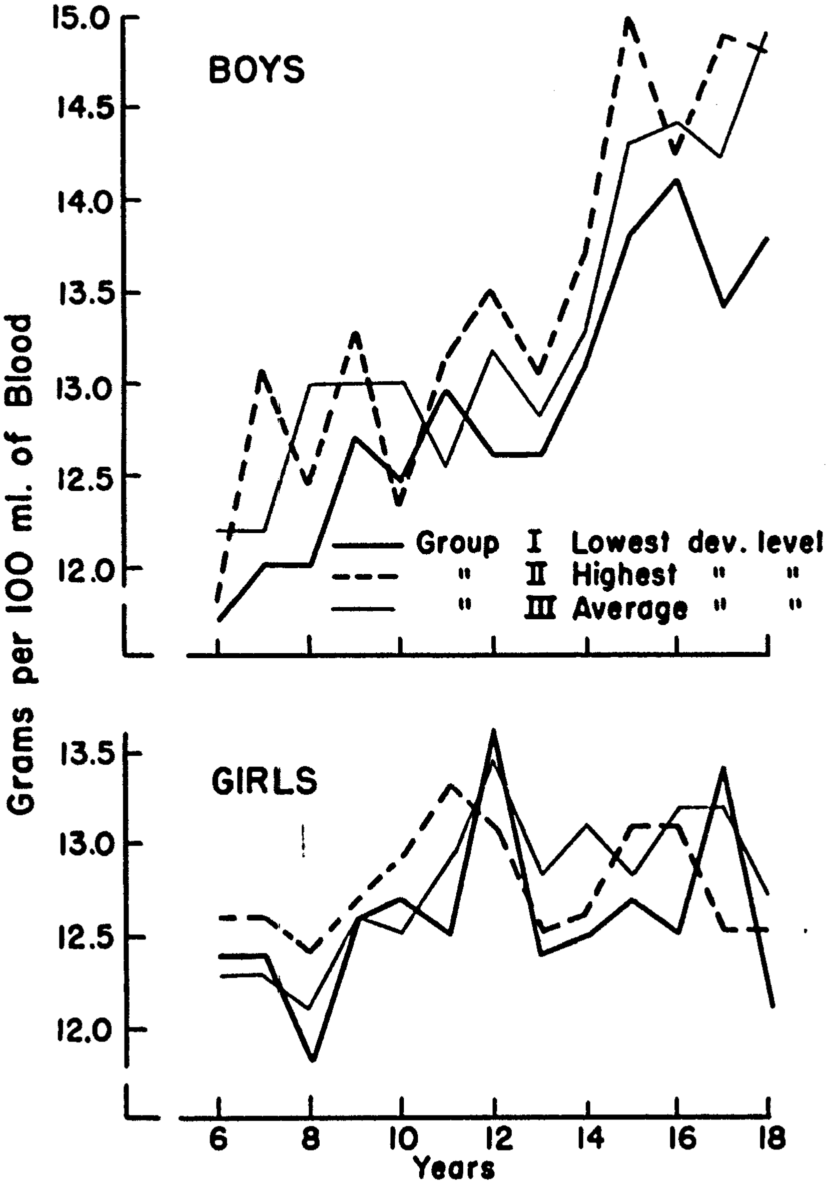

Fig. 28 Mean hemoglobin concentration in blood of Iowa children classified according to three developmental levels

Table 49

Regression of Developmental Levels on Dietary Components of the Diets of Three Groups of Iowa Children

Dietary components	Group I (Lowest developmental level) Regression coefficient	Mean D.L.	Mean intake	Group II (Highest developmental level) Regression coefficient	Mean D.L.	Mean intake
			Boys			
	No. = 67			No. = 83		
Calories	0.031 ± 0.006[a]	83.3	2485 cal.	0.027 ± 0.005[a]	137.3	2786 ca
Protein	0.962 ± 0.198[a]		75 gm.	0.764 ± 0.158[a]		86 gm.
Calcium	0.001 ± 0.013		833 mg.	0.178 ± 0.011		1185 m
Iron	4.962 ± 1.058[a]		12 mg.	5.531 ± 1.056[a]		13 mg.
Ascorbic acid	0.174 ± 0.311		76 mg.	0.021 ± 0.099		94 mg.
Thiamine	49.167 ± 3.432[a]		1.2 mg.	47.589 ±10.832[a]		1.4 mg
Riboflavin	27.355 ± 5.452[a]		1.8 mg.	16.790 ± 5.330[a]		2.3 mg
Niacin	3.282 ± 0.773[a]		13 mg.	3.850 ± 0.853[a]		15 mg.
			Girls			
	No. = 87			No. = 97		
Calories	0.028 ± 0.006[a]	83.7	2276 cal.	0.013 ± 0.006[b]	139.2	2297 c
Protein	0.770 ± 0.182[a]		72 gm.	0.850 ± 0.154		76 gm.
Calcium	0.024 ± 0.013		926 mg.	-0.018 ± 0.008[b]		997 mg
Iron	5.921 ± 1.202[a]		11 mg.	2.575 ± 3.053		11 mg.
Ascorbic acid	0.209 ± 0.082[b]		80 mg.	0.013 ± 0.103		88 mg.
Thiamine	59.312 ±10.811[a]		1.1 mg.	11.649 ±14.271		1.1 mg
Riboflavin	16.695 ± 7.031[b]		1.8 mg.	-6.572 ± 4.971		1.9 mg
Niacin	3.708 ± 1.045[a]		12 mg.	2.799 ± 0.975[a]		12 mg.

[a]Significant at 1% level

[b]Significant at 5% level

Table 49

ression of Developmental Levels on Dietary Components of the Diets of Three Groups of Iowa Children

ental level)		Group II (Highest developmental level)			Group III (Average developmental level)		
Mean D.L.	Mean intake	Regression coefficient	Mean D.L.	Mean intake	Regression coefficient	Mean D.L.	Mean intake
		Boys					
7		No. = 83			No. = 431		
83.3	2485 cal.	0.027 ± 0.005[a]	137.3	2786 cal.	0.035 ± 0.002[a]	108.1	2683 cal.
	75 gm.	0.764 ± 0.158[a]		86 gm.	1.530 ± 0.040[a]		81 gm.
	833 mg.	0.178 ± 0.011		1185 mg.	0.019 ± 0.005[a]		1135 mg.
	12 mg.	5.531 ± 1.056[a]		13 mg.	6.336 ± 0.360[a]		12 mg.
	76 mg.	0.021 ± 0.099		94 mg.	0.249 ± 0.042[a]		86 mg.
	1.2 mg.	47.589 ±10.832[a]		1.4 mg.	58.978 ±27.860[b]		1.3 mg.
	1.8 mg.	16.790 ± 5.330[a]		2.3 mg.	18.283 ± 2.494[a]		2.2 mg.
	13 mg.	3.850 ± 0.853[a]		15 mg.	5.233 ± 0.036[a]		14 mg.
		Girls					
7		No. = 97			No. = 411		
83.7	2276 cal.	0.013 ± 0.006[b]	139.2	2297 cal.	0.030 ± 0.004[a]	105.7	2318 cal.
	72 gm.	0.850 ± 0.154		76 gm.	0.745 ± 0.107[a]		70 gm.
	926 mg.	-0.018 ± 0.008[b]		997 mg.	0.002 ± 0.006		951 mg.
	11 mg.	2.575 ± 3.053		11 mg.	6.141 ± 0.663[a]		11 mg.
	80 mg.	0.013 ± 0.103		88 mg.	0.168 ± 0.035[a]		80 mg.
	1.1 mg.	11.649 ±14.271		1.1 mg.	40.187 ± 6.253[a]		1.1 mg.
	1.8 mg.	-6.572 ± 4.971		1.9 mg.	7.896 ± 3.577[b]		1.8 mg.
	12 mg.	2.799 ± 0.975[a]		12 mg.	4.615 ± 0.611[a]		12 mg.

Table 50

Regression of Developmental Levels on Concentrations of Blood Constituents of Three Groups of Iowa Childr

	Group I (Lowest developmental level)			Group II (Highest developmental level		
Blood constituents	Regression coefficient	Mean D.L.	Mean %	Regression coefficient	Mean D.L.	Mean %
			Boys			
Ascorbic acid	No. = 37 -20.885 ± 16.089	78.7	0.68 mg.	No. = 54 -28.945 ± 9.086[a]	136.3	0.81
Carotenoids	No. = 37 0.015 ± 0.125	75.3	106.3 mcg.	No. = 52 -0.253 ± 0.096[a]	136.9	110.7
Alk. phosphatase	No. = 39 -0.347 ± 2.497	77.5	5.34 BPU	No. = 54 -2.702 ± 2.429	136.2	5.31
Hemoglobin	No. = 66 15.062 ± 2.426[a]	83.5	12.8 gm.	No. = 80 12.901 ± 2.575[a]	138.8	13.3
			Girls			
Ascorbic acid	No. = 50 -21.548 ± 9.108[b]	81.6	0.84 mg.	No. = 49 -6.708 ± 11.230	136.6	0.81
Carotenoids	No. = 49 -0.115 ± 0.154	81.4	105 mcg.	No. = 49 -0.422 ± 0.085[a]	135.0	105
Alk. phosphatase	No. = 52 -6.812 ± 2.562[a]	80.7	4.06 BPU	No. = 39 -5.370 ± 1.638[a]	135.8	5.00
Hemoglobin	No. = 85 1.955 ± 2.873	84.0	12.7 gm.	No. = 93 2.116 ± 7.861	139	12.8

[a]Significant at 1% level

[b]Significant at 5% level

Table 50

ssion of Developmental Levels on Concentrations
ood Constituents of Three Groups of Iowa Children

;	ental level)		Group II (Highest developmental level)			Group III (Average developmental level)		
	Mean D.L.	Mean %	Regression coefficient	Mean D.L.	Mean %	Regression coefficient	Mean D.L.	Mean %
			Boys					
)7			No. = 54			No. = 238		
	78.7	0.68 mg.	−28.945 ± 9.086[a]	136.3	0.81 mg.	−14.632 ± 4.977[a]	102.0	0.78 mg.
)7			No. = 52			No. = 231		
	75.3	106.3 mcg.	−0.253 ± 0.096[a]	136.9	110.7 mcg.	−0.084 ± 0.010[a]	105.0	106.0 mcg.
)9			No. = 54			No. = 234		
	77.5	5.34 MPU	−2.702 ± 2.429	136.2	5.31 MPU	0.003 ± 0.059	105.1	5.33 MPU
56			No. = 80			No. = 431		
	83.5	12.8 gm.	12.901 ± 2.575[a]	138.8	13.3 gm.	14.931 ± 1.541[a]	105.0	13.2 gm.
			Girls					
50			No. = 49			No. = 226		
	81.6	0.84 mg.	−6.708 ± 11.230	136.6	0.81 mg.	−13.063 ± 1.091[a]	104.3	0.81 mg.
49			No. = 49			No. = 228		
	81.4	105 mcg.	−0.422 ± 0.085[a]	135.0	105 mcg.	−0.152 ± 0.050[a]	104.8	112 mcg.
52			No. = 39			No. = 223		
	80.7	4.06 MPU	−5.370 ± 1.638[a]	135.8	5.00 MPU	−3.280 ± 0.917[a]	104.3	4.81 MPU
85			No. = 93			No. = 400		
	84.0	12.7 gm.	2.116 ± 7.861	139	12.8 gm.	7.548 ± 1.363[a]	106.0	12.8 gm.

These facts about the regressions may help the reader to interpret the data presented in the tables. If the regression coefficient is significant, it represents the amount of change in developmental level with each unit change in food energy or dietary nutrients, or each unit change in the concentration of the blood constituents. If the regression coefficient is negative and significant, it denotes a decrease in developmental level with each unit increase in food energy or dietary nutrients, or concentration of blood constituents. When positive and significant, the regression coefficient shows that the developmental level increased with each unit of food energy or other nutrients, or with each unit of increase in concentration of blood constituents. If it is not significant, the mean intake or concentration of the blood constituent of the group at the mean developmental level of the total group is representative of the whole group regardless of developmental level. For example, in Table 49, the coefficient of the regression of developmental level on calcium was not significant for the boys in Group I (lowest developmental level); therefore the mean intake of the group, 833 milligrams at the mean developmental level (83.3) of the group may be considered representative of the intakes for all the boys in Group I.

Nutrient intake. For the boys of average developmental level (Group III) the developmental level increased with each unit increase in food energy and in the nutrients of the diet. Except for calcium and ascorbic acid, the boys of highest developmental level displayed the same significant relationships. The mean calcium and ascorbic acid content of the diets of the boys in Group II at the mean developmental level of the group was greater than the corresponding means for the boys of average developmental level (Group III) (see Table 49). The boys of lowest developmental level (Group I) had no significant increase in developmental level per unit of intake of ascorbic acid or calcium. The mean intake at the mean developmental level was lower than the corresponding intakes for the average group. Except for these two nutrients the relationships of developmental level to intakes were significant in each of the three classifications according to developmental level (Groups I, II, III). At the mean developmental levels for each group, the mean daily food energy value and nutrient intakes of boys, varied in the same direction as developmental level classification.

For the girls of lowest developmental level (Group I) and for those of average developmental level (Group III), the developmental level increased with each unit increase in food energy and in other nutrients of the diet except calcium. The mean calcium intake at the mean developmental level for both groups was practically the same.

Of all the groups studied the girls with the highest developmental level had the fewest significant relationships between developmental level and nutrient intake. The only highly significant developmental level-nutrient relationship within this group was with niacin. The caloric intake was positively related at the 5 per cent level. The calcium intake of the girls in the highest developmental level was also significant at the 5 per cent level, but in a negative direction. In other words, the developmental level of the girls of the highest developmental level was inversely related to the calcium intakes.

For the girls of the highest developmental level, the developmental level was not significantly related to nutrient intake. The mean nutrient intakes for the group were either the same or slightly larger than the means for the girls of the lowest developmental level. Girls of the highest developmental levels had apparently larger mean daily intakes of protein, ascorbic acid and riboflavin than did the girls in the lowest developmental level at the mean developmental level of each of the two groups; but they had exactly the same mean daily intakes of iron and thiamine.

Concentrations of various blood constituents. The developmental level of the boys in Groups II and III decreased significantly with each milligram per cent increase of serum ascorbic acid. In other words, the boys in Groups II and III who had the greatest developmental levels had less serum ascorbic acid than the boys who had the smallest developmental level in each group (see Table 50). The boys in Group I had a mean concentration of 0.68 milligram per cent at the mean developmental level (78.7).

The developmental level of the girls in Groups I and III decreased significantly with each unit increase of serum ascorbic acid concentration. So, the girls in Groups I and III who had the greatest developmental levels had less serum ascorbic acid than the girls who had the least developmental level in each group. The girls in Group II did not exhibit a significant relationship between developmental level and serum ascorbic acid concentration. The mean concentrations of serum ascorbic acid for all three groups at the mean developmental level were about the same; namely, 0.84, 0.81 and 0.81 milligram per cent at developmental levels of 81.6, 104.3 and 136.6, respectively.

The developmental level of the girls and boys in Groups II and II decreased significantly with each increase in serum concentration of carotenoids. The developmental level of the girls and boys in Group I was not significantly related to serum carotenoid concentration. The mean serum carotenoid concentration for the boys was 106.3 micrograms per cent and for the girls 105.0 micrograms per cent at the mean developmental levels of 75.3 and 81.4, respectively.

For boys and girls of average developmental level, there was a significant increase in developmental level with increases in concentration of hemoglobin. The same relationship was observed for boys of highest and lowest developmental level. However, the girls of the highest and lowest developmental levels showed no increase in developmental level with increases of hemoglobin concentrations in the blood. The mean hemoglobin concentrations for each group of girls was practically the same. For Group I, it was 12.7 grams per cent at the mean developmental level, 84.0, and 12.8 grams per cent at the mean developmental level of 106 for Group II.

Since developmental level increases with age, the two factors are involved in the relationships just described. Therefore, it was decided to examine the relationship between developmental level and protein intake in each age-sex group.

In Table 51 are presented the regression coefficient, the standard error of the coefficient and the means of the developmental level and the means of the protein intake for each age and sex group.

The age factor had been removed somewhat from this analysis since the regressions were computed separately for each yearly age group in which the children were not divided according to developmental level but were considered as a total group. The relationship between developmental level and the protein intake within each age was not so significant as it was when considered separately for the three developmental level groups over the entire age range. The 7-, 8-, 11-, 13- and 14-year-old boys, and the 8- and 10-year-old girls showed a significant increase in developmental level with each gram of protein ingested. Another noteworthy observation was that the girls at 7, 9, 12, 14, 15, 16 and 18 years displayed a decrease in developmental level with increased intake of protein. This technique of handling nutritional data needs further consideration. It may be worthwhile to examine the

Table 51

Regression of Developmental Levels on Protein Content of the Diets of Iowa Children

Age	No.	Regression coefficient	Mean D.L.	Mean protein intake gms.
		Boys		
6	37	0.18 ± 0.18	53	67
7	56	0.39 ± 0.15[b]	64	65
8	54	0.74 ± 0.23[a]	77	70
9	53	0.15 ± 0.14	91	74
10	60	0.04 ± 0.14	96	74
11	50	0.48 ± 0.16[a]	107	79
12	90	0.20 ± 0.29	115	85
13	44	0.54 ± 0.13[a]	132	86
14	39	0.11 ± 0.04[a]	140	89
15	32	0.04 ± 0.12	160	93
16	31	0.07 ± 0.17	163	99
17	20	-0.07 ± 0.22	164	105
18	17	0.10 ± 0.18	167	102
		Girls		
6	50	0.21 ± 0.68	50	60
7	48	-0.16 ± 0.22	64	61
8	43	0.50 ± 0.20[b]	69	64
9	62	-0.33 ± 0.27	85	70
10	61	0.52 ± 0.20[b]	99	68
11	58	0.20 ± 0.14	113	69
12	81	-0.21 ± 0.15	126	80
13	44	0.29 ± 0.15	129	74
14	37	-0.02 ± 0.07	140	75
15	38	-0.25 ± 0.52	150	75
16	36	-0.16 ± 0.18	151	70
17	25	0.03 ± 0.14	152	72
18	12	-0.37 ± 0.18	147	74

[a] Significant at 1 per cent level.

[b] Significant at 5 per cent level.

relationship between developmental level and protein intake when the protein intake is computed per unit of developmental level for each individual.

This analysis showed that throughout the range of school age, the children with average developmental level, had highly significant relationships between developmental level and nutrient intake, except for calcium. At a given age, however, as shown by the computed regressions of developmental level on protein intake, the relationship was close only at specified ages. Differences in developmental level at a single age were small as compared with those throughout the age range.

Summary

1. At most ages boys of the highest developmental level had dietary intakes of food energy and of nutrients that were greater than the intakes of boys of the lowest developmental level.

2. From 6 to 13 years boys of average developmental level tended to have diets with mean intakes intermediate to those of the other two groups. After 13 years the trend was irregular.

3. Except for calcium the boys of the highest and those of average developmental levels tended to have diets with nutrient intakes equal to or in excess of the allowances. The calcium content of the diets of boys of teen-ages deviated most often from the allowances.

4. The boys of the lowest developmental level had diets in which nutrient values were less than the allowances at more ages than boys at the other developmental levels.

5. From 6 to 11 years the girls of the highest developmental level tended to have dietary intakes of the various nutrients that were greater than those of the girls of lowest developmental level. Contrary to expectation after 11 years the girls of lowest developmental level tended to have nutrient intakes greater than those of the girls in the highest developmental level.

6. The girls of average developmental levels had diets with food energy values and nutrient content that were intermediate to the other two groups from 6 to 9 years; afterwards, there was no consistent relationship between developmental level and dietary intakes.

7. In general the girls in the highest and average developmental levels from 6 to 10 or 12 years had diets with food energy values and nutrient content, except calcium,

that exceeded or approached the allowances. Afterwards the girls had dietary intakes of these nutrients that were often below the allowances.

8. The serum ascorbic acid concentrations of the girls and boys in all developmental level groups decreased with age from 1.0 to 0.8 milligram per cent at 6 years to 0.3 to 0.5 milligram per cent at 13 to 15 years.

9. The serum carotenoid concentrations of the boys and girls with the highest developmental level showed the most drastic reduction in the concentration of the serum carotenoids between the ages of 11 and 15 years for the boys and between 9 and 10 years for the girls. The girls and boys in the other groups did not have as marked a reduction in the serum concentrations of carotenoids.

10. The peak, or the maximum level of the serum alkaline phosphatase concentration, came a year earlier for the girls and boys in the highest developmental level than for those in the lowest and average developmental levels.

11. The boys and girls in the lowest developmental levels tended to have lower hemoglobin concentrations than those of highest or average levels.

12. The developmental level of the boys of average developmental level increased significantly with each unit of food energy and of other nutrients of the diet. The

developmental level of the boys in groups of highest and lowest developmental levels increased significantly with increases in calorie intake and the intake of dietary nutrients, except calcium and ascorbic acid. The boys in the highest developmental level had higher mean intakes in these two nutrients than the boys in the lowest developmental level.

13. For the girls of the lowest developmental level and in average developmental level the developmental level increased with increase in nutrient intake, except calcium. The mean calcium intake for the girls in both groups was alike. The girls of the highest developmental level had significant positive relationships between developmental level and calories and niacin but a significantly negative relationship with calcium. The mean intake of the other nutrients was similar to the means of the girls in the lowest developmental level.

14. For the girls and boys in the average developmental level group, a significant decrease in developmental level occurred as the serum ascorbic acid or carotenoid concentrations increased. The relationship was less consistent for the girls and boys in the other two groups.

15. The boys increased significantly in developmental level with increases in hemoglobin concentration in the

blood. For the girls the relationship was apparent only in the group of average developmental level.

16. The relationship between developmental level and protein intake was not so apparent when the effect of age was partially removed.

CONCENTRATIONS OF BLOOD CONSTITUENTS OF IOWA CHILDREN IN RELATION TO NUTRIENT INTAKE, BODY MEASUREMENTS AND TO EACH OTHER

Serum Ascorbic Acid Concentration of Iowa Children

The function of ascorbic acid in the synthesis of intercellular material has been known to nutritionists for a long time. Recently evidence has been disclosed for other uses of ascorbic acid by the organism. Sealock and Silberstein (1939) observed in scorbutic guinea pigs and Levine, Marples and Gordon (1939) observed in premature infants that very low ascorbic acid intakes were associated with abnormalities in the metabolism of tyrosine and phenylalanine. They concluded that vitamin C is needed for the body to utilize these amino acids efficiently.

Within the past year King and co-workers (1953) noted that scorbutic animals did not utilize the acetate radical in the synthesis of cholesterol.

In children it is important to maintain a high degree of tissue saturation since they are building body tissue and since they are apt to be easily infected by communicable diseases.

King (1938) found that growing tissues were richer in vitamin C than adult tissue, also that tissues with high metabolic activity were rich in the vitamin. It has also been shown by King and Menten (1935) that the reduction of the serum ascorbic acid concentrations lowered the resistence of the organism to bacterial toxins. Hamil et al. (1938) observed that children with low ascorbic acid intakes showed no scorbutic symptoms except when the low intake of the child was accompanied by an infection. After the infection was relieved, the symptoms disappeared, although the intake of ascorbic acid was not changed. The phagocytic activity of white blood cells is dependent upon the concentration of ascorbic acid in the blood. The maximum activity was obtained at the concentrations of 0.7 milligram per cent (Ames and Nungester, 1947).

There is a consensus that a satisfactory serum ascorbic acid concentration for children lies between 0.7 to 1.0 milligram per cent. Moyer and co-workers (1948) in reviewing the literature for criteria to evaluate vitamin C concentrations of American children found very few investigators considered that it was necessary to have concentrations of 0.7 milligram per cent as a satisfactory concentration. Most of them used 0.4 milligram per cent or less as the criterion for satisfactory concentrations of ascorbic acid. Values below 0.4 milligram per cent are believed by other investigators to represent unsatisfactory concentrations.

<u>Mean serum ascorbic acid concentrations of total sample of Iowa children</u>

Serum ascorbic acid concentrations were obtained on 329 boys and 326 girls ranging in age from 6 to 18 years. These children lived in large cities or small towns in Iowa.

The blood samples were obtained during the school years 1949 to 1951. A single observation was made on each child. The value of the concentration of serum ascorbic acid for each child was the mean of at least three determinations. One observation on a single individual may not be a good indicator of a single individual's status with respect to ascorbic acid nutrition. Yet, a single observation on a group of individuals may give a good estimate of the status of ascorbic acid nutrition of the population under study. Moyer <u>et</u> <u>al</u>. (1948) noted that the variation between determinations is less than the variation between day to day observations. The variation in an individual's ascorbic acid concentration from day to day was also observed by Storvick and her associates (1950) in their study of ascorbic acid needs for boys and girls during puberty.

The mean serum concentrations of ascorbic acid for Iowa children of each age and sex tended to decrease irregularly with age. The lowest concentrations were obtained at 14 to 18 years for the boys and at 13 to 14 years for the girls (see Table 52). In the late teens the girls had higher concentrations which may indicate that the great need of the vitamin for growth had decreased. Therefore, the mean ascorbic acid intake approximating the allowances did maintain a satisfactory blood level, when the stress of growth had been removed. It may be noted that low concentrations occurred for a span of three years surrounding puberty in both sexes.

The mean daily ascorbic acid content of the diets of the boys 14 to 18 years and of the girls 13 to 15 years either exceeded or approximated the allowances. Storvick _et al_. (1947) observed that adolescent boys and girls could not maintain tissue saturation at intakes equal to the allowances. Young and Pilcher (1950) suggested 25 per cent of the calculated dietary intakes of ascorbic acid be deducted for losses in preparation and during storage. Even with this consideration the vitamin C intake would not account entirely for the low concentrations noted during puberty.

The decrease in serum ascorbic acid concentrations with age was observed by Clayton _et al_. (1953) in serum ascorbic acid concentrations of children in the Northeast

Table 52

Mean Serum Ascorbic Acid Concentrations of Iowa Children

Age yr.	No.	Mean mg.%	Standard deviation mg. %	Standard error mg. %	Range mg.%
			Boys		
6	21	0.91	0.57	0.12	0.30 - 2.18
7	26	0.83	0.46	0.09	0.16 - 1.79
8	37	0.86	0.51	0.08	0.15 - 2.00
9	35	1.07	0.57	0.10	0.15 - 1.85
10	32	0.80	0.43	0.08	0.14 - 1.74
11	24	0.88	0.48	0.10	0.33 - 1.87
12	64	0.72	0.39	0.05	0.22 - 1.74
13	27	0.70	0.50	0.10	0.15 - 1.81
14	17	0.56	0.35	0.08	0.15 - 1.60
15	14	0.50	0.22	0.06	0.19 - 0.88
16	15	0.56	0.35	0.09	0.15 - 1.19
17	7	0.60	0.32	0.12	0.21 - 1.94
18	10	0.47	0.42	0.13	0.13 - 1.34
			Girls		
6	24	0.96	0.53	0.11	0.19 - 1.87
7	31	1.05	0.49	0.08	0.26 - 2.10
8	25	0.94	0.61	0.12	0.20 - 2.50
9	37	0.94	0.58	0.09	0.14 - 2.47
10	28	1.00	0.58	0.11	0.28 - 1.92
11	34	0.70	0.35	0.06	0.23 - 1.64
12	62	0.73	0.44	0.06	0.16 - 2.29
13	25	0.49	0.31	0.06	0.12 - 1.27
14	13	0.58	0.46	0.13	0.09 - 1.69
15	15	0.47	0.29	0.07	0.12 - 1.25
16	15	0.67	0.50	0.12	0.16 - 1.62
17	10	1.01	0.62	0.20	0.22 - 1.95
18	7	1.00	0.56	0.20	0.27 - 1.69

Region. These investigators observed a sex difference at 13 to 15 years. This sex difference may be due to the differences in the rate of maturation usually found between sexes. At 13 years the girls had a lower concentration than the boys. At 17 and 18 years the girls had a much higher concentration than the boys. The boys at these ages continued to have low concentrations noted at puberty.

The range for each age-sex group extended from somewhat less than 0.2 milligram per cent to approximately 2.0 milligrams per cent. Although the highest levels around the age of puberty were low as compared with the highest at other ages, the mean daily vitamin C intake increased rather than decreased with age. The changes must have been affected by factors related to their physiological development.

Study of three groups of boys and girls classified according to serum ascorbic acid concentrations

To study the characteristics of individuals who had a particularly low or high serum ascorbic acid concentration, each age-sex group was divided into three groups according to the mean and standard deviation. In Group I were all the individuals who had serum ascorbic acid concentrations in the second or third standard deviation below the mean; in Group II, those in the second and third standard deviation above the mean; in Group III, those within plus or minus one standard deviation.

In Table 53 are presented the mean serum ascorbic acid concentrations of the three groups by age and sex. Again the concentrations of each group decreased irregularly with age to the minima at the age interim 13 through 18 years for boys and 13 to 16 years for girls (see Figure 29).

The boys and girls in Group II were able to maintain the "so-called satisfactory level" during puberty while the children in Group I could not. A mean serum concentration of 0.8 was observed for the 15 year old boys in Group II on a mean calculated intake of 117 milligrams of dietary ascorbic acid. The boys in Group II had mean serum concentrations of 0.8 to 1.80 milligrams per cent which they maintained with mean daily intakes of 81 to 158 milligrams.

The girls in Group II were able to maintain a concentration of 1.00 milligram per cent or higher at a mean daily intake of ascorbic acid varying from 85 to 92 milligrams. The girls and boys in Group I had concentrations of about 0.2 to 0.3 milligram per cent on intakes ranging

Table 53

Mean Serum Ascorbic Acid Concentrations of Iowa Children Classified According to Levels of Ascorbic Acid Concentrations

Groups[a]	I		II		III	
Age yr.	No.	Mg.%	No.	Mg.%	No.	Mg.%
			Boys			
6	3	0.32	4	1.80	14	0.78
7	5	0.28	6	1.51	15	0.74
8	9	0.27	6	1.63	22	0.89
9	7	0.29	7	1.83	21	1.08
10	7	0.25	7	1.43	18	0.77
11	4	0.36	5	1.54	15	0.80
12	8	0.28	10	1.44	46	0.64
13	5	0.17	5	1.52	17	0.62
14	1	0.15	2	1.28	14	0.49
15	3	0.24	3	0.81	8	0.48
16	3	0.17	3	1.08	9	0.52
17	1	0.21	2	0.97	4	0.75
18	0	--	2	1.24	8	0.28
			Girls			
6	5	0.31	6	1.66	13	0.88
7	6	0.41	6	1.75	19	1.03
8	3	0.25	5	1.87	17	0.80
9	6	0.28	7	1.88	24	0.84
10	5	0.33	7	1.78	16	0.87
11	4	0.30	5	1.37	25	0.63
12	7	0.22	13	1.42	42	0.61
13	3	0.15	5	1.02	17	0.40
14	1	0.09	2	1.46	10	0.46
15	1	0.12	2	1.02	12	0.40
16	1	0.16	2	1.60	12	0.56
17	2	0.23	2	1.84	6	0.99
18	1	0.27	2	1.68	5	0.68

Groups - Serum ascorbic acid concentrations
- I — Minus 2 or 3 standard deviations.
- II — Plus 2 or 3 standard deviations.
- III — Within ± 1 standard deviation.

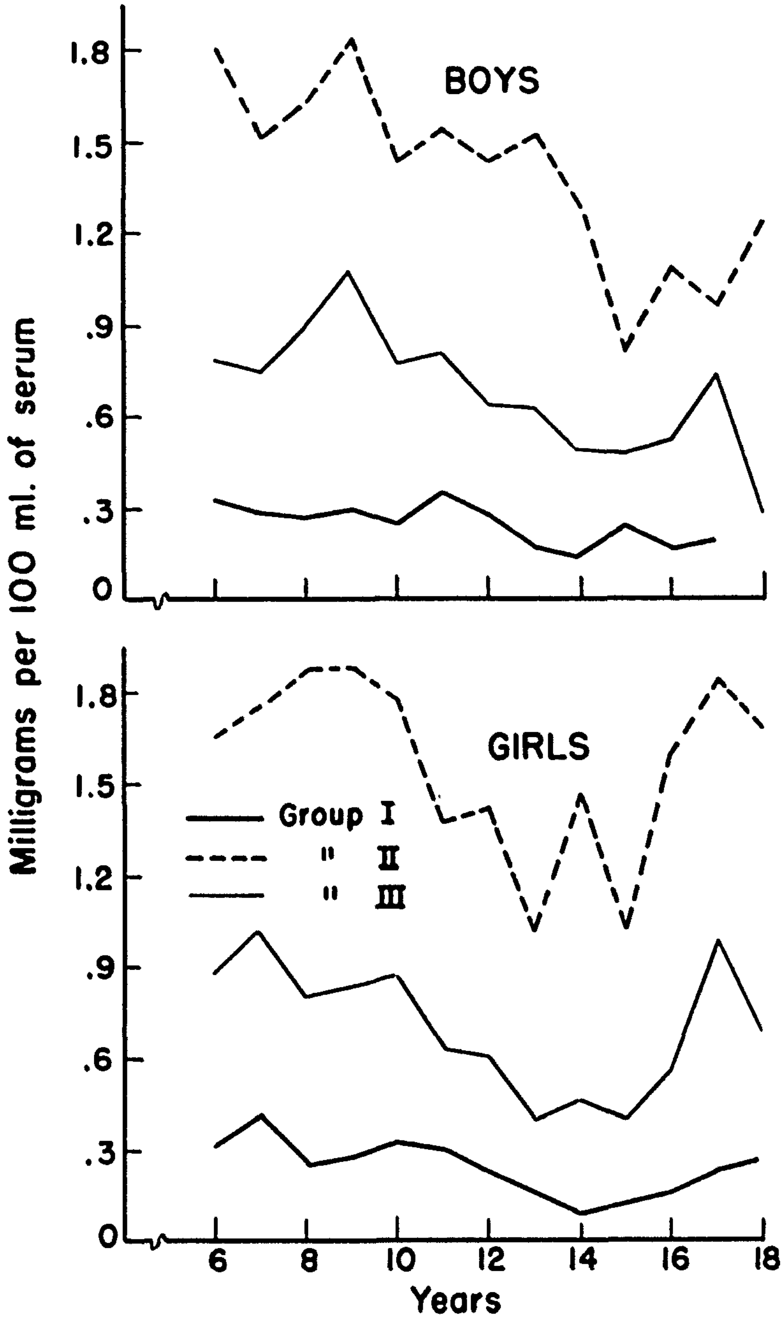

Fig. 29 Mean serum ascorbic acid concentration of Iowa children classified according to three groups of ascorbic acid concentrations

from 45 to 60 milligrams of ascorbic acid (see Figure 30).

The low serum ascorbic acid concentrations in Group I were associated with low intakes (see Table 54). A group of British workers (Vitamin C Sub-Committee, 1948) claimed that 35 milligrams would maintain a satisfactory serum ascorbic acid concentration. Williams and co-workers (1951) found 35 milligrams or less of dietary ascorbic acid to be associated with 0.8 milligram per cent of serum ascorbic acid in the Groton Township study. Williams in his analysis of the data disregarded age and sex. The mean intakes of Iowa children in Group I were not so low as those found by British workers and Williams, yet the serum concentrations were in the unsatisfactory ranges.

Babcock _et al_. (1953) suggested that the relationship between dietary intake and the concentration of the corresponding constituent in the blood might be expected to be higher in the lower levels than in the higher. The simple correlation was calculated to obtain the degree of relationship between the serum ascorbic acid concentrations and ascorbic acid intake of Groups I and II and for the boys and the girls. The correlation coefficients were:

	Boys	Girls
Group I	0.17	-0.11
Group II	-0.06	0.11 .

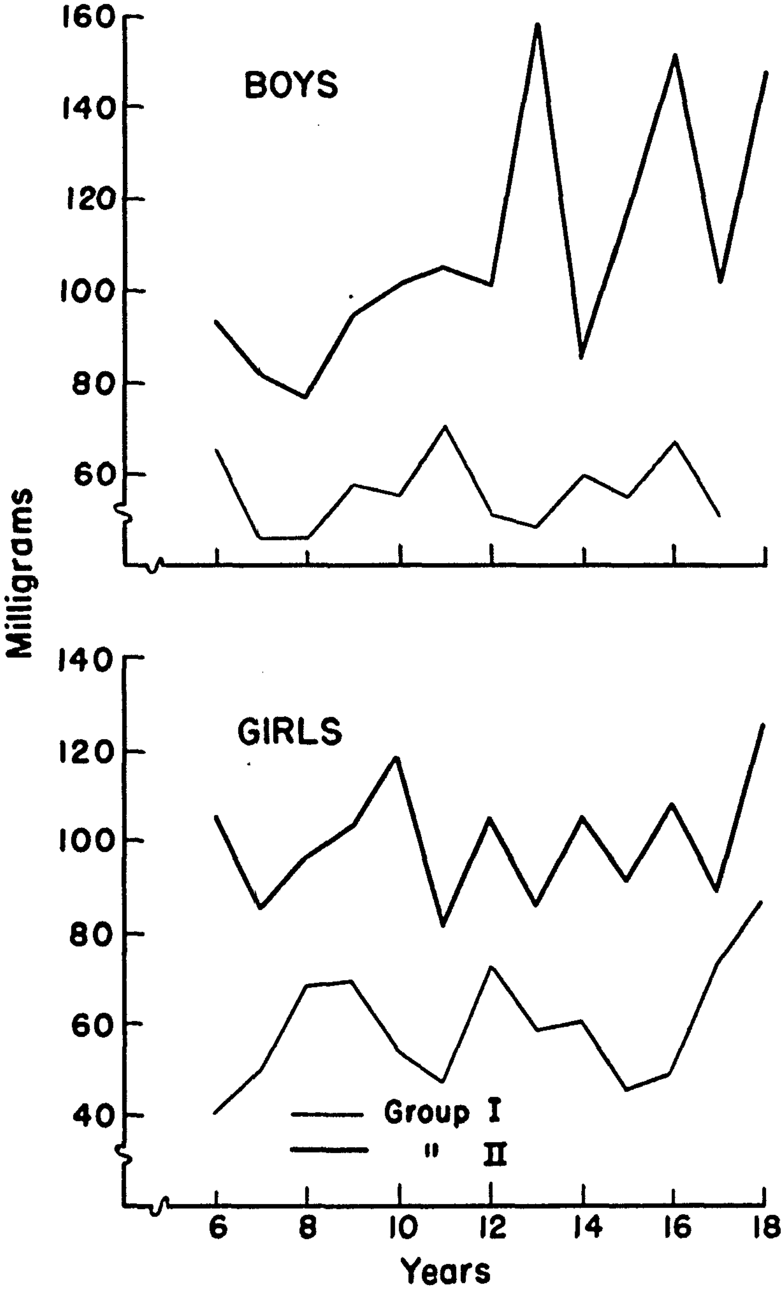

Fig. 30 Mean daily ascorbic acid contents of the diets of two groups of Iowa children classified according to serum ascorbic acid concentration

Table 54

Mean Serum Ascorbic Acid Concentration and Mean Ascorbic Acid Content of the Diets of Two Groups of Iowa Children

Groups[a]	I		II	
Age yr.	Serum concentration mg.%	Intake mgs.	Serum concentration mg.%	Intake mgs.
		Boys		
6	0.32	65	1.80	93
7	0.28	45	1.51	81
8	0.27	46	1.63	76
9	0.29	58	1.83	95
10	0.25	55	1.43	101
11	0.36	71	1.54	105
12	0.28	51	1.44	101
13	0.17	49	1.52	158
14	0.15	60	1.28	85
15	0.24	55	0.81	117
16	0.17	68	1.08	151
17	0.21	51	0.97	101
18	--	--	1.24	148
		Girls		
6	0.31	40	1.66	106
7	0.41	49	1.75	84
8	0.25	68	1.87	96
9	0.28	69	1.88	103
10	0.33	54	1.78	118
11	0.30	47	1.37	80
12	0.22	71	1.42	106
13	0.15	59	1.02	85
14	0.09	61	1.46	105
15	0.12	45	1.02	92
16	0.16	49	1.60	109
17	0.23	73	1.84	89
18	0.27	87	1.68	125

[a]Groups - Serum ascorbic acid concentrations
I Minus 2 or 3 standard deviations.
II Plus 2 or 3 standard deviations.

They were not significant. The highly significant relationship reported by other investigators was not apparent in the Iowa data. The relationship in the Iowa data may have been reduced by the fact that only segments of the entire sample of boys and girls were used in the analysis.

Moschette and co-workers (1952) obtained a highly significant relationship between serum ascorbic acid concentration and vitamin C intake ($r = 0.45$). Babcock et al. (1953) secured a correlation coefficient of 0.24 between serum concentration and intake of ascorbic acid of the New York children, and 0.42 for the Maine children. The highly significant relationship may be partially due to the large number of observations in the analysis, also to the limited age range in the studies of Moschette and Babcock.

Physical status. The boys and girls in Group II tended to be slightly taller than the children in Group I. This observation was especially notable among the girls and boys from 6 to 13 years. It appeared from these data that the serum concentration of ascorbic acid is related to linear growth, although the difference between the two groups was small. In 9 of the 13 age groups the girls with highest serum ascorbic acid concentrations were taller than the girls with the lowest at corresponding ages. For the boys the same relationship was noted in 8 of the 13 age groups. The relationship was continuous from 6 through 13 years.

No similar relationship was noted between serum ascorbic acid concentration and weight. The boys in Group I tended to be slightly heavier than the boys of Group II. For the girls the opposite was observed, the girls in Group II were slightly heavier than Group I.

Nutrient intake. The mean nutrient intake of the diets of the boys and girls in Groups I and II are presented in Tables 55 and 56. There was no relationship between serum ascorbic acid concentration of the boys and girls in Groups I and II and the caloric value of their diets.

There was a marked difference in the protein intake of children in the two groups. With a few exceptions the children, both the boys and the girls, in Group II (highest serum ascorbic acid concentration) had diets with higher protein content than the children in Group I (lowest serum ascorbic acid concentration). This relationship may be associated with the economic status of the children for Pilcher et al. (1950) have shown that as the expenditure for food increased so did the consumption of foods rich in ascorbic acid and protein.

Table 55

**Mean Daily Food Energy and Nutrient Content of Diets of Iow
Children Classified According to Serum Ascorbic Acid Concent**

Boys

Age in yrs.	No.	Group[a]	mg. %	Food energy cal.	Protein gm.	Calcium mg.	Iron mg.	Vitamin A value	Ascor aci m
6	3	I	0.32	2310	73	1099	10	4641	6
	4	II	1.80	2304	68	1211	9	7023	9
7	5	I	0.28	2035	63	1063	10	4823	4
	6	II	1.51	2035	65	1035	10	6009	8
8	9	I	0.27	2242	69	1115	9	3913	4
	6	II	1.63	2246	74	1164	10	8244	7
9	7	I	0.29	2487	75	1060	12	10944	5
	7	II	1.83	2576	83	1134	12	9383	9
10	7	I	0.25	2419	74	900	12	5155	5.
	7	II	1.43	2377	75	971	11	9338	10
11	4	I	0.36	2670	77	1150	11	5791	7.
	5	II	1.54	2589	80	1188	11	7987	10,

[a]Group	Serum Ascorbic Acid Concentrations
I	Minus 2 or 3 standard deviations
II	Plus 2 or 3 standard deviations

Table 55

ly Food Energy and Nutrient Content of Diets of Iowa
Classified According to Serum Ascorbic Acid Concentration

Boys

Food energy cal.	Protein gm.	Calcium mg.	Iron mg.	Vitamin A value	Ascorbic acid mg.	Thiamine mg.	Ribo-flavin mg.	Niacin mg.
2310	73	1099	10	4641	65	1.1	2.0	12
2304	68	1211	9	7023	93	1.1	2.0	10
2035	63	1063	10	4823	45	0.9	1.8	10
2035	65	1035	10	6009	81	1.0	1.9	12
2242	69	1115	9	3913	46	1.0	2.0	12
2246	74	1164	10	8244	76	1.0	2.1	12
2487	75	1060	12	10944	58	1.2	2.3	14
2576	83	1134	12	9383	95	1.2	2.2	15
2419	74	900	12	5155	55	1.1	1.8	15
2377	75	971	11	9338	101	1.1	1.8	14
2670	77	1150	11	5791	71	1.1	2.1	12
2589	80	1188	11	7987	105	1.7	2.1	12

ncentrations

deviations

eviations

Table 55 (continued)

Age in yrs.	No.	Group[a]	mg. %	Food energy cal.	Protein gm.	Calcium mg.	Iron mg.	Vitamin A value	Ascorb acid mg.
12	8	I	0.28	2590	80	1134	12	5597	51
	10	II	1.44	2769	91	1283	13	11119	101
13	5	I	0.17	2671	82	1252	12	3921	49
	5	II	1.52	2832	90	1463	13	12446	158
14	1	I	0.15	2953	82	622	16	4460	60
	2	II	1.28	2934	80	886	12	4370	85
15	3	I	0.24	2718	72	864	12	8657	55
	3	II	0.81	3266	107	1214	15	6264	117
16	3	I	0.17	3479	91	957	14	4515	64
	3	II	1.08	3177	104	1543	16	15976	151
17	1	I	0.21	3636	102	1089	15	4848	51
	2	II	0.97	3669	123	2082	16	7046	101
18	0	I	-	-	-	-	-	-	-
	2	II	1.24	3684	119	1394	17	9818	142

Food energy cal.	Protein gm.	Calcium mg.	Iron mg.	Vitamin A value	Ascorbic acid mg.	Thiamine mg.	Ribo-flavin mg.	Niacin mg.
2590	80	1134	12	5597	51	1.3	2.2	14
2769	91	1283	13	11119	101	1.4	2.3	15
2671	82	1252	12	3921	49	1.2	2.2	13
2832	90	1463	13	12446	158	1.5	2.8	15
2953	82	622	16	4460	60	1.4	1.6	15
2934	80	886	12	4370	85	1.2	1.9	16
2718	72	864	12	8657	55	1.1	1.7	12
3266	107	1214	15	6264	117	1.5	2.3	19
3479	91	957	14	4515	64	1.5	1.9	18
3177	104	1543	16	15976	151	1.7	2.8	18
3636	102	1089	15	4848	51	1.6	2.2	17
3669	123	2082	16	7046	101	1.7	3.4	18
-	-	-	-	-	-	-	-	-
3684	119	1394	17	9818	142	1.7	2.9	20

Table 56

Mean Daily Food Energy and Nutrient Content of Diets of Iow Children Classified According to Serum Ascorbic Acid Concen

Girls

Age in yrs.	No.	Group[a]	mg.%	Food energy cal.	Protein gm.	Calcium mg.	Iron mg.	Vitamin A value	Ascor ac m
6	5	I	0.31	1925	60	939	9	4409	4
	6	II	1.66	2048	63	914	10	7719	10
7	6	I	0.41	1856	55	858	8	4176	4
	6	II	1.75	1993	60	970	8	8178	8
8	3	I	0.25	1957	57	867	8	2942	6
	5	II	1.87	2157	72	1230	10	10292	9
9	6	I	0.28	2362	65	874	10	5601	6
	7	II	1.88	2371	75	1013	12	9336	10
10	5	I	0.33	2283	69	1013	10	5508	5
	7	II	1.78	2218	76	1191	11	11774	11
11	4	I	0.30	2248	68	904	10	5237	4
	5	II	1.37	2218	71	939	10	6068	8

[a]Group	Serum Ascorbic Acid Concentrations
I	Minus 2 or 3 standard deviations
II	Plus 2 or 3 standard deviations

Table 56

ily Food Energy and Nutrient Content of Diets of Iowa
n Classified According to Serum Ascorbic Acid Concentration

Girls

Food energy cal.	Protein gm.	Calcium mg.	Iron mg.	Vitamin A value	Ascorbic acid mg.	Thiamine mg.	Ribo-flavin mg.	Niacin mg.
1925	60	939	9	4409	40	0.9	1.6	10
2048	63	914	10	7719	106	1.0	1.7	11
1856	55	858	8	4176	49	0.9	1.5	10
1993	60	970	8	8178	84	1.0	1.8	9
1957	57	867	8	2942	68	1.0	1.5	9
2157	72	1230	10	10292	96	1.1	2.3	10
2362	65	874	10	5601	69	1.1	1.8	13
2371	75	1013	12	9336	103	1.2	2.1	14
2283	69	1013	10	5508	54	1.0	1.8	12
2218	76	1191	11	11774	118	1.2	2.3	12
2248	68	904	10	5237	47	1.0	1.8	11
2218	71	939	10	6068	80	1.2	1.9	13

Concentrations

rd deviations

l deviations

Table 56 (continued)

Age in yrs.	No.	Group[a]	mg. %	Food energy cal.	Protein gm.	Calcium mg.	Iron mg.	Vitamin A value	Ascor aci mg
12	7	I	0.22	2777	80	971	13	5713	71
	13	II	1.42	2630	82	1188	12	7835	106
13	3	I	0.15	1975	60	814	9	6278	59
	5	II	1.02	2422	78	1013	11	5866	85
14	1	I	0.09	2489	81	1352	11	6010	61
	2	II	1.46	2586	88	1285	13	10077	105
15	1	I	0.12	2632	69	545	12	16733	45
	2	II	1.02	2695	84	1192	12	8136	92
16	1	I	0.16	1756	42	426	7	1793	49
	2	II	1.60	2310	74	1190	11	6546	109
17	2	I	0.23	2890	81	927	15	12872	73
	2	II	1.84	2202	71	965	10	4630	89
18	1	I	0.27	3024	91	630	14	14983	87
	2	II	1.68	1961	62	824	10	4458	125

Food energy cal.	Protein gm.	Calcium mg.	Iron mg.	Vitamin A value	Ascorbic acid mg.	Thiamine mg.	Ribo-flavin mg.	Niacin mg.
2777	80	971	13	5713	71	1.3	1.8	14
2630	82	1188	12	7835	106	1.3	2.2	14
1975	60	814	9	6278	59	1.0	1.6	11
2422	78	1013	11	5866	85	1.2	1.8	14
2489	81	1352	11	6010	61	1.2	2.4	14
2586	88	1285	13	10077	105	1.3	2.2	13
2632	69	545	12	16733	45	1.1	2.1	16
2695	84	1192	12	8136	92	1.0	2.1	12
1756	42	426	7	1793	49	0.8	0.9	8
2310	74	1190	11	6546	109	1.2	2.2	12
2890	81	927	15	12872	73	1.4	1.9	16
2202	71	965	10	4630	89	1.1	1.8	11
3024	91	630	14	14983	87	1.4	1.1	21
1961	62	824	10	4458	125	1.1	1.6	11

With the exception of the 7-year-old boys and the 14-year-old girls, the calcium intake of the children in Group II was higher than that for the children in Group I.

There was a tendency for the iron content of the diets of the children in Group II to be higher than that for the children in Group I.

The diets of the boys and girls in Group II tended to have higher vitamin A values than the diets of the children in Group I.

The mean daily thiamine, riboflavin and niacin contents of the diets of the children in Group II tended to be greater than those of the boys and girls in Group I (see Tables 55 and 56).

From these data it appeared that children who had the highest serum ascorbic acid concentration had diets richer in protein, minerals and vitamins than those of children with lowest serum concentrations of ascorbic acid. From these findings it appeared that children with lowest serum ascorbic acid concentrations lived on a nutritional plane considerably lower than the children with the highest serum concentration of ascorbic acid. The effects of other dietary deficiencies than ascorbic acid must be considered in the evaluation of nutritional status in respect to ascorbic acid.

Concentrations of various blood constituents. For the children of the highest, lowest and average concentrations of ascorbic acid, the serum carotenoid concentrations followed the trends similar to those of the concentrations of serum ascorbic acid. The minima of the serum carotenoid concentrations in the three groups of boys and girls appeared within two years after the minima for the serum ascorbic acid. From these data it seemed that both blood constituents are utilized rapidly by the growing child in the formation of new tissue whether it be bone or muscle (see Table 57).

The boys with the highest serum ascorbic acid concentration reached the maximum in serum alkaline phosphatase concentration at 13 years, the boys with the lowest concentration of serum ascorbic acid reached the maximum at 15 years. It may be concluded that the boys in Group II matured earlier than did the boys in Group I (see Table 58).

The girls with the lowest serum ascorbic acid concentration had an especially high concentration of serum alkaline phosphatase at 10 and 11 years, during the interim when the greatest increment in height was made.

With a few exceptions the girls with the highest serum ascorbic acid concentrations tended to have higher hemoglobin concentrations in the blood than the girls with the

Table 57

Mean Serum Carotenoid Concentrations of Iowa Children Classified According to Serum Ascorbic Acid Concentrations

Groups[a]	I		II		III	
Age yr.	No.	Mcg.%	No.	Mcg.%	No.	Mcg.%
			Boys			
6	3	121	4	107	14	102
7	5	100	5	117	15	136
8	9	81	6	124	19	130
9	6	74	6	128	19	115
10	7	82	7	146	20	130
11	3	97	5	138	16	127
12	8	84	10	113	47	108
13	5	75	5	146	16	100
14	1	51	2	150	14	83
15	3	62	3	104	7	64
16	2	54	3	76	8	92
17	1	78	2	81	4	151
18	0	--	2	96	8	96
			Girls			
6	3	77	5	129	16	153
7	6	114	6	150	19	116
8	3	114	5	150	17	106
9	6	79	6	130	26	117
10	5	99	7	173	16	118
11	4	83	5	116	26	106
12	7	76	11	114	54	81
13	3	60	5	110	17	84
14	1	111	2	110	10	90
15	1	77	2	98	12	101
16	1	41	2	114	11	93
17	2	130	2	152	6	105
18	1	126	2	182	4	116

[a]Groups - Serum ascorbic acid concentrations

- I — Minus 2 or 3 standard deviations.
- II — Plus 2 or 3 standard deviations.
- III — Within ± 1 standard deviation.

Table 58

Mean Serum Alkaline Phosphatase Concentrations of Iowa Children Classified According to Serum Ascorbic Acid Concentrations

Groups[a]	I		II		III	
Age yr.	No.	NP.U.[b]	No.	NP.U.	No.	NP.U.
			Boys			
6	3	5.05	4	4.77	14	4.25
7	4	4.80	6	5.41	15	5.16
8	9	4.69	6	4.80	22	5.80
9	7	6.19	7	5.76	21	5.59
10	7	3.58	7	5.15	18	5.14
11	5	4.87	5	5.17	15	5.46
12	8	5.73	9	5.29	46	6.25
13	5	6.03	4	7.90	17	6.18
14	1	4.16	2	4.48	14	6.36
15	3	7.87	3	4.27	8	5.07
16	3	6.59	3	3.06	9	3.81
17	1	4.06	2	3.58	4	1.31
18	--	--	2	2.07	8	2.53
			Girls			
6	5	4.54	6	4.98	13	5.16
7	6	5.16	6	4.37	19	5.02
8	3	4.34	5	5.52	17	4.75
9	6	4.41	7	6.19	24	5.47
10	5	7.67	7	4.62	16	5.59
11	4	9.13	5	6.00	25	5.48
12	7	5.51	13	5.44	42	5.36
13	3	5.53	5	3.85	17	4.22
14	1	2.19	2	4.55	10	2.93
15	1	1.66	2	1.81	12	2.86
16	1	2.87	2	2.09	12	1.94
17	2	1.22	2	1.84	6	1.60
18	1	1.56	2	2.33	4	1.29

[a]Groups - Serum ascorbic acid concentrations
I Minus 2 or 3 standard deviations
II Plus 2 or 3 standard deviations
III Within ± 1 standard deviation

[b]Nitrophenol units.

lowest concentration of ascorbic acid. The boys showed no outstanding differences in hemoglobin with serum ascorbic acid concentration (see Table 59).

Summary

1. The serum concentrations of ascorbic acid of boys and girls decreased irregularly with age. The lowest concentrations were attained at 14 to 18 years for boys and 13 through 15 years for girls.

2. Dietary intakes of ascorbic acid equal to the allowances did not maintain a uniformly high serum ascorbic acid concentrations at all ages during the school years. The serum concentrations of ascorbic acid were evidently influenced by the intake and by physiological changes accompanying growth.

3. The children with low serum ascorbic acid concentrations did have a lower intake of vitamin C than did the children with the highest serum ascorbic acid concentration, but a significant relationship was not noted in the correlation between serum concentration and intake of ascorbic acid of the two extreme groups of children.

4. The children with the highest serum ascorbic acid tended to be slightly taller than the children with the lowest serum ascorbic acid concentration.

Table 59

Mean Hemoglobin Concentrations in Blood of Iowa Children Classified According to Serum Ascorbic Acid Concentrations

Groups[a]	I		II		III	
Age yr.	No.	Gm. %	No.	Gm. %	No.	Gm. %
			Boys			
6	3	12.7	4	12.2	14	13.4
7	5	12.8	5	13.3	15	12.6
8	9	13.4	6	13.1	22	12.8
9	6	13.3	6	13.4	21	13.2
10	7	12.8	7	12.9	18	13.3
11	4	13.4	5	13.2	15	13.1
12	7	13.5	10	13.4	46	13.4
13	3	13.9	4	13.6	17	13.5
14	1	14.7	2	12.8	14	13.4
15	3	14.0	3	14.5	8	14.7
16	3	14.5	3	14.2	9	15.0
17	1	13.6	2	14.8	4	14.3
18	--	--	2	16.0	8	14.9
			Girls			
6	4	13.5	6	12.4	13	12.7
7	6	12.7	5	13.2	19	12.8
8	1	12.7	4	13.1	17	12.5
9	6	12.2	7	12.9	24	12.9
10	5	12.6	7	13.3	16	12.9
11	4	13.4	5	12.8	25	13.3
12	7	13.9	13	13.5	42	13.4
13	3	11.9	5	12.9	17	12.8
14	1	13.2	2	14.5	10	14.0
15	1	12.1	2	13.0	12	13.1
16	1	14.0	2	13.9	12	13.2
17	2	12.4	2	14.0	6	13.2
18	1	12.3	2	13.2	4	12.4

[a]Groups - Serum ascorbic acid concentrations
I Minus 2 or 3 standard deviations
II Plus 2 or 3 standard deviations
III Within ± 1 standard deviation.

5. The children with the highest serum ascorbic acid concentrations tended to have diets richer in protein, minerals and vitamins than the children with the lowest concentration of serum ascorbic acid.

6. The concentrations of serum carotenoids followed the same trend as of serum ascorbic acid.

7. The girls with the lowest serum ascorbic acid concentration had an especially high concentration of serum alkaline phosphatase during the interim of rapid linear growth (10 to 13 years). The boys with the highest serum ascorbic acid concentration reached the maximum concentration in alkaline phosphatase two years earlier than did the boys with the lowest serum ascorbic acid concentrations.

8. The girls with the highest serum ascorbic acid concentration tended to have slightly higher mean hemoglobin concentrations in the blood than had the girls of the other two groups.

Serum Carotenoid Concentration of Iowa Children

To date there is little evidence that the carotenoids as such function in the human body, although it has been suggested by Szymanski and Longwell (1951) that the carotenoid concentrations may be related to the rate of growth. A study of the possible functions of the carotenoids is complicated by the fact that the body is able to transform these substances to vitamin A which, in turn, the body uses or stores.

Animal experimentations (Weise et al., 1947) have shown that the main site of conversion is the intestinal wall. A certain percentage of the carotenoid substances must be allowed to pass through the intestinal wall unchanged, since carotenoids are found in the blood combined with protein. Apparently other tissues must be able to convert the carotenoids to vitamin A (Bieri and Pollard, 1953).

The concentrations of the carotenoids in the serum reflect the dietary intake of foods rich in this substance. British workers (Report of Vitamin A Sub-Committee, 1945) noted that the serum carotenoid concentration of a group of healthy men dropped notably after subsisting on diets free of carotenes and vitamin A for one week. Pilcher et al. (1950) observed that the consumption of carotene-rich foods increased with the amount of money spent for food. Yarbrough and Dann (1941) found higher serum vitamin A concentrations in subjects of a high-income level than in those of a low-income level.

Investigators do not agree on a concentration of serum carotenoids that is satisfactory. Some investigators believe that 125 to 75 micrograms per cent should be the lower limit (Bessey and Lowry, 1947); others, 100 to 50 micrograms per cent (Goldsmith, 1950; Sinclair, 1950). Williams and co-workers (1950) arbitrarily selected 60 micrograms per cent as the dividing line between satisfactory and unsatisfactory concentrations.

Mean serum carotenoid concentration of a total sample of Iowa children

The mean serum concentration of the carotenoids for each age-sex group declined irregularly to a minimum at 15 years for the boys and at 13 years for the girls (see Table 60). Clayton *et al*. (1953) noted a similar decline in the means of the different school age groups. In that study the children in the 13 to 15 year old group had lower mean concentration of serum carotenoids than the children in the other age groups.

These investigators also observed that the girls tended to have higher mean concentrations than the boys. The Iowa girls appeared to have a similar tendency except at the ages 11 to 13 years, usually regarded as the period of puberty. Some of this sex difference found in the early teens may be due to the different ages of puberty for the two sexes. A more valid comparison of serum carotenoid

Table 60

Mean Serum Carotenoid Concentration of Iowa Children

Age yr.	No.	Mean mcg.%	Standard deviation mcg.%	Standard error mcg.%	Range mcg.%
			Boys		
6	21	106	12.9	2.8	26 - 180
7	25	125	47.3	9.5	66 - 262
8	34	116	45.0	7.7	41 - 217
9	31	110	37.3	6.7	40 - 212
10	34	124	47.4	8.1	49 - 220
11	26	116	42.2	8.3	69 - 268
12	65	106	38.8	4.8	43 - 204
13	26	104	47.3	9.3	32 - 210
14	17	89	31.4	7.6	41 - 169
15	13	72	30.1	8.4	44 - 157
16	13	82	46.8	13.0	28 - 218
17	7	106	37.1	14.0	52 - 154
18	10	96	37.6	11.9	33 - 161
			Girls		
6	24	139	54.6	11.1	49 - 248
7	31	122	40.3	7.2	48 - 209
8	25	116	47.8	9.6	58 - 262
9	38	113	34.4	5.6	58 - 206
10	28	128	59.7	11.3	65 - 367
11	35	105	39.2	6.6	47 - 180
12	62	99	31.8	4.0	40 - 194
13	25	86	38.3	7.7	31 - 192
14	13	95	33.2	9.2	49 - 174
15	15	99	26.8	6.9	64 - 133
16	14	92	29.9	8.0	41 - 146
17	10	120	38.8	12.3	66 - 188
18	7	136	34.6	13.1	91 - 198

concentrations between the two sexes would be obtained by disregarding chronological age and by matching the data at the ages when the lowest concentrations occurred. The comparison would be made according to physiological development rather than chronological age. When the Iowa data was considered in the above manner, the mean serum concentrations of the girls tended to be slightly higher than those of the boys at most ages.

Based on comparisons at chronological ages, an opposite tendency was noted by Szymanski and Longwell (1951) in their longitudinal study on Denver children. From 6 to 14 years the median for the girls at each chronological age was lower than for the boys.

The low serum carotenoid concentrations during periods of rapid growth cannot be fully explained by a low intake of food rich in carotenoids. The entire sample of children had diets with mean vitamin A values that exceeded the allowances at all ages in both sexes (see Table 12).

In order to explore the relationships between the serum carotenoid concentrations and the vitamin A value of the diet, several simple correlations were computed from the data on the boys. The correlations were between serum concentration of carotenoids and vitamin A value of diet, the vitamin A value from vegetable sources, and age.

A multiple regression was computed between serum carotenoid concentration, vitamin A value from vegetable sources and age.

Over one-third of the vitamin A value in the diets of the boys came from vegetable sources. The mean daily vitamin A value of the intake of the 305 boys was estimated to be 7641 International Units, with 2755 International Units derived from vegetable sources. Macy (1948) noted a definite rise in the carotenoid concentrations of a group of children, after they had consumed a diet rich in fruits and vegetables for two weeks (Robinson et al., 1948). Therefore high carotenoid intake may be expected to be reflected in the serum concentrations of Iowa boys.

The correlation between the serum carotenoid concentration and the total vitamin A value of the diets of the boys was small ($r = 0.15$) but significant. Moschette et al. (1952) obtained a similar value for the correlation between the same two variables. In the Iowa data the relationship was more significant when only the vitamin A value for vegetable sources was considered ($r = 0.21$).

The correlation between age and serum concentration of carotenoids was significant but negative ($r = -0.20$).

The relationship between serum carotenoid concentration and carotenoid intake became greater when age was considered as another independent variable. The multiple R in this calculation was 0.35, which is highly significant. It may be concluded from this analysis that the serum carotenoid is related not only to intake, but also to age.

Indications from the study of Iowa boys are that the serum concentrations did reflect intakes of dietary carotene, but the changes accompanying puberty caused a rapid reduction of the substance in the serum. The conversion of carotenoids to vitamin A may be rapid during prepubertal periods of growth. This finding suggested an increased need of vitamin A during this period. The allowances recommended for age do not take into consideration the great needs of the body during this period.

Study of the three groups of Iowa children classified according to serum carotenoid concentrations

To study the characteristics of individuals who had particularly low or high serum carotenoid concentrations, each age-sex group was divided into three groups according to the mean and standard deviation. In Group I were all the individuals who had serum carotenoid concentrations in the second or third standard deviations below the mean;

in Group II those in the second and third standard deviation above the mean; in Group III, those within plus or minus one standard deviation.

The mean concentrations for each of the small groups are presented in Table 61. In both sexes the mean serum concentration for each age in the three groups tended to decrease irregularly with age. The minima for each group may be noted at 13 to 15 years for the boys and 13 to 16 years for the girls (see Figure 31).

By comparing the mean daily vitamin A values of the diets of Groups I and II it was evident that girls with low or high serum concentrations of carotenoids had diets correspondingly low or high in vitamin A value. The only exception was at 13 years of age. For the younger boys (7 to 12 years) high serum carotenoid concentrations were accompanied with high mean daily intakes of vitamin A, the low concentrations with low intakes of the vitamin (see Figure 32). The dietary relationship was conspicuously absent for the teen-age boys.

Although the mean serum carotenoid concentration of each age-sex group tended to reflect the intake of vitamin A rich-foods, the correlation between the two variables was negligible, when the entire Groups I or II of the boys and of the girls (6-18 years) was considered in the correlation.

Table 61

Mean Serum Carotenoid Concentrations of the Three Groups of Iowa Children

Groups[a]	I		II		III	
Age yr.	No.	Mcg.%	No.	Mcg.%	No.	Mcg.%
Boys						
6	3	50	3	169	15	104
7	3	70	4	213	18	114
8	5	58	6	193	23	109
9	5	58	5	166	21	108
10	6	60	6	202	22	120
11	3	70	3	198	20	111
12	10	58	12	169	43	99
13	5	46	3	195	18	105
14	3	47	2	150	12	89
15	0	--	1	157	12	65
16	2	48	1	218	10	79
17	1	52	2	150	4	98
18	1	33	1	161	8	96
Girls						
6	4	58	3	240	17	140
7	5	66	5	185	21	121
8	2	60	4	197	19	105
9	5	68	6	171	26	112
10	1	65	1	367	26	122
11	4	55	6	171	25	97
12	9	57	10	151	43	96
13	3	37	4	153	18	79
14	2	54	2	154	9	90
15	4	68	3	132	8	102
16	2	48	3	136	9	87
17	1	66	2	182	7	109
18	1	91	1	198	5	133

[a]Group - Serum carotenoid concentrations
I Minus 2 or 3 standard deviations
II Plus 2 or 3 standard deviations
III Within ± 1 standard deviation.

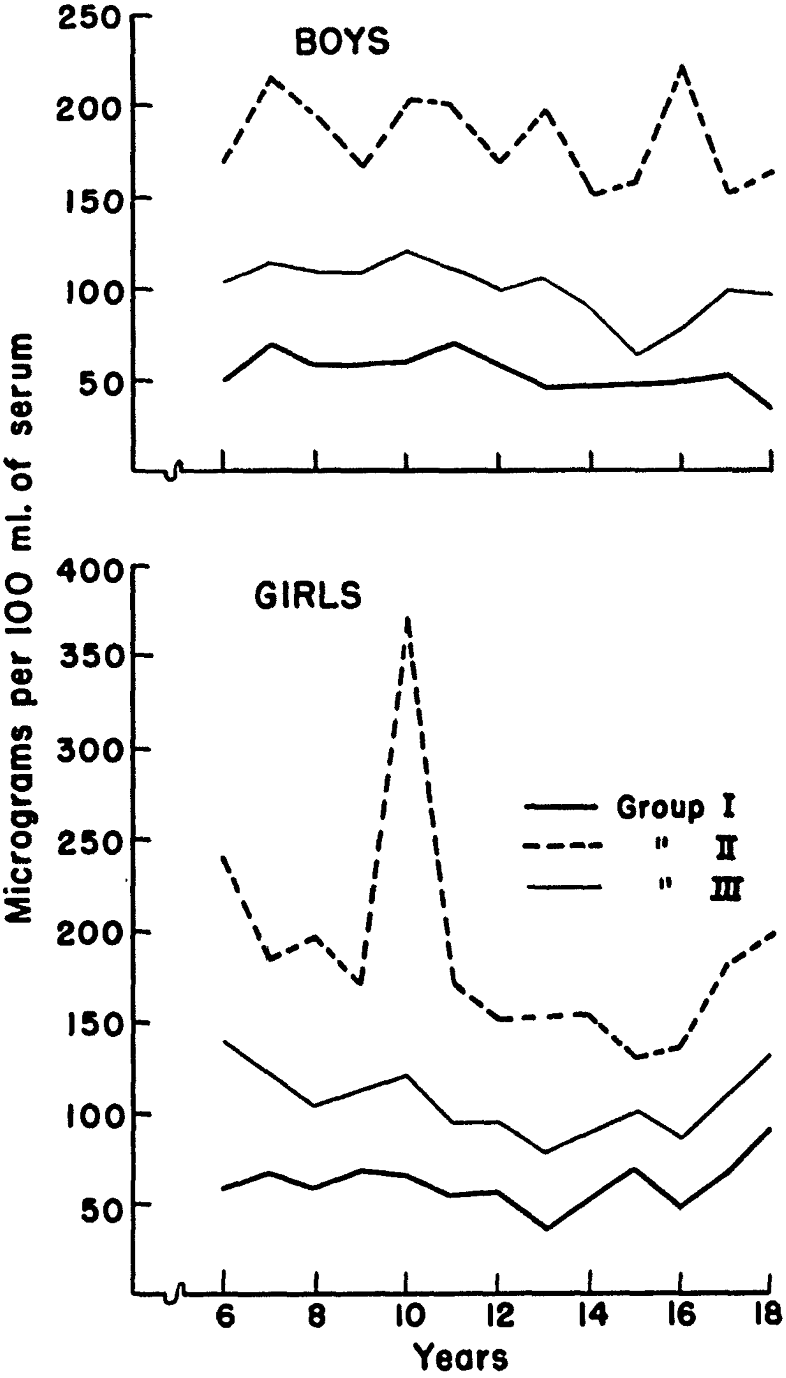

Fig. 31 Mean serum carotenoid concentration of Iowa children classified according to level of carotenoid concentration

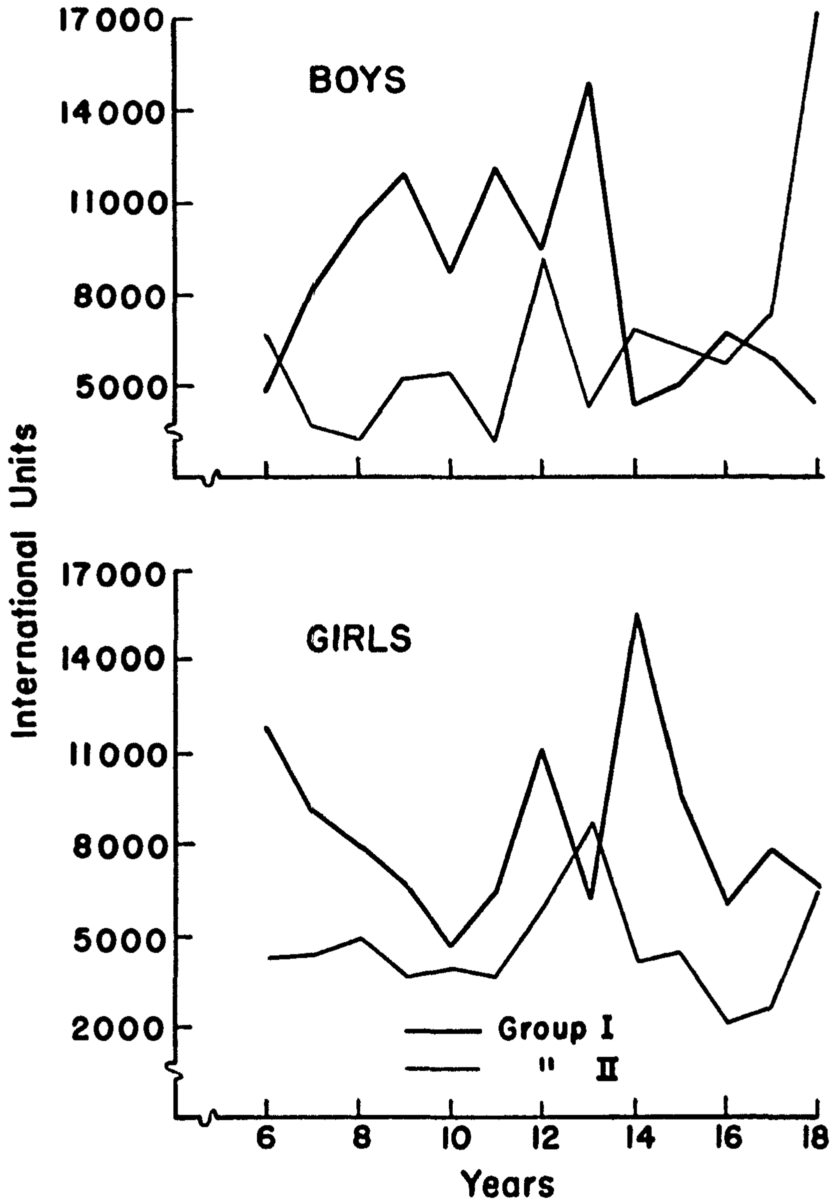

Fig. 32 Mean daily vitamin A value of the diets of Iowa children classified according to two groups of serum carotenoid concentration

	Boys	Girls
Group I	-0.21	-0.07
Group II	0.15	-0.07

Merrow *et al*. (1952) classified the serum carotenoid concentrations of the Vermont children according to the standards of Bessey and Lowry. The children whose serum concentrations were excellent or good were placed into the high group, and those whose concentrations were fair or poor, in the low group. The investigators then studied the relationship between the total vitamin A value of the diets of the children and the concentration of the serum carotenoids. They reported that significant relationship existed between total vitamin A value of the diets and the serum concentration of carotenoids. The two studies on the Iowa children and Vermont children values of serum carotenoids do show a relationship between the intake and serum concentration of the carotenoids.

Physical status. From 6 to 12 years the boys with low serum carotenoid concentrations had slightly lighter weights than the boys with high serum carotenoid concentrations. For the boys from 12 to 18 years and the girls from 6 to 18 years no relationship was evident between serum carotenoid concentration and weight.

The boys from 6 to 12 years in Group I were slightly shorter than the boys in Group II. During puberty the girls and boys with high serum carotenoid concentrations tended to be shorter than the children in Group I.

Nutrient intake. The mean nutrient intake of the diets of the boys and girls in Groups I and II are presented in Tables 62 and 63. There was a tendency for the boys and girls with the high serum carotenoid concentration to have a higher caloric intake than the children with low serum concentrations. This tendency was observed in 9 out of 13 age groups. The girls in Group II had diets with higher protein content than the girls in Group I. The boys were not as consistent as the girls in the relationship between serum concentration and protein intake.

The girls in Group II had diets with higher iron and calcium contents than had the girls in Group I. The relationship between serum carotenoid concentrations and the calcium content of the diets of the boys was less noticeable than it was for the girls. The iron content of the boys' diets seemed to follow the same direction as the concentration of the serum carotenoid.

Both the boys and the girls with high serum carotenoid concentration tended to have high intakes of ascorbic acid. The children with low concentrations had low intakes of vitamin C (see Figure 33).

Table 62

Mean Daily Food Energy and Nutrient Content of Diets o
Iowa Children According to Serum Carotenoid Concentrat

Boys

Age in yrs.	No.	Group[a]	Blood carotene	Food energy cal.	Protein gm.	Calcium mg.	Iron mg.	Vitamin A value	Asc ac m
6	3	I	50	2377	68	1120	9	6732	[illegible]
	3	II	169	2143	62	921	10	4864	[illegible]
7	3	I	70	1700	56	953	8	3690	[illegible]
	4	II	213	1936	65	998	9	8163	[illegible]
8	5	I	58	2383	70	1112	10	3223	[illegible]
	6	II	193	2218	74	1152	10	10042	[illegible]
9	5	I	58	2106	59	827	9	5222	[illegible]
	5	II	166	2114	68	988	11	11938	[illegible]
10	6	I	60	2421	73	1023	10	5476	[illegible]
	6	II	202	2143	69	1085	10	8667	[illegible]
11	3	I	70	2485	73	1076	9	3088	[illegible]
	3	II	198	2882	88	1209	13	12099	[illegible]

[a]Group	Serum Carotenoid Concentration
I	Minus 2 or 3 standard deviations
II	Plus 2 or 3 standard deviations

Table 62

an Daily Food Energy and Nutrient Content of Diets of
wa Children According to Serum Carotenoid Concentrations

Boys

Food energy cal.	Protein gm.	Calcium mg.	Iron mg.	Vitamin A value	Ascorbic acid mg.	Thiamine mg.	Ribo-flavin mg.	Niacin mg.
2377	68	1120	9	6732	48	1.1	2.1	12
2143	62	921	10	4864	59	1.0	1.6	10
1700	56	953	8	3690	36	0.8	1.5	9
1936	65	998	9	8163	74	0.9	1.9	11
2383	70	1112	10	3223	67	1.1	1.9	12
2218	74	1152	10	10042	95	1.1	2.0	12
2106	59	827	9	5222	52	1.0	1.6	11
2114	68	988	11	11938	97	1.1	2.0	12
2421	73	1023	10	5476	49	1.0	1.9	14
2143	69	1085	10	8667	75	1.1	2.0	12
2485	73	1076	9	3088	54	1.0	2.0	14
2882	88	1209	13	12099	108	1.4	2.2	14

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Table 62 (continued)

Age in yrs.	No.	Group[a]	Blood carotene	Food energy cal.	Protein gm.	Calcium mg.	Iron mg.	Vitamin A value	Ascorbic acid mg.
12	10	I	58	2703	84	1236	12	9064	80
	12	II	169	2704	86	1168	13	9322	86
13	5	I	46	2717	76	919	12	4155	49
	3	II	195	2903	102	1707	15	14824	169
14	3	I	47	2648	80	1051	12	6905	60
	2	II	150	2934	80	886	12	4370	85
15	0	I	-	-	-	-	-	-	-
	1	II	157	3684	126	1383	16	5072	127
16	2	I	31	3368	104	1392	13	5751	64
	1	II	218	3368	96	1150	14	6762	110
17	1	I	52	3898	132	2422	16	7367	77
	2	II	150	3252	99	1406	15	5880	79
18	1	I	33	2945	111	1597	12	17019	56
	1	II	161	2992	75	571	13	4398	39

Food energy cal.	Protein gm.	Calcium mg.	Iron mg.	Vitamin A value	Ascorbic acid mg.	Thiamine mg.	Ribo-flavin mg.	Niacin mg.
2703	84	1236	12	9064	80	1.4	2.4	15
2704	86	1168	13	9322	86	1.3	2.1	14
2717	76	919	12	4155	49	1.3	1.8	14
2903	102	1707	15	14824	169	1.8	3.2	18
2648	80	1051	12	6905	60	1.3	2.1	13
2934	80	886	12	4370	85	1.2	1.7	16
-	-	-	-	-	-	-	-	-
3684	126	1383	16	5072	127	1.7	2.6	25
3368	104	1392	13	5751	64	1.4	2.7	16
3368	96	1150	14	6762	110	1.9	2.2	16
3898	132	2422	16	7367	77	1.7	3.8	19
3252	99	1406	15	5880	79	1.6	2.6	15
2945	111	1597	12	17019	56	1.6	3.9	20
2992	75	571	13	4398	39	1.1	1.4	12

Table 63

Mean Daily Food Energy and Nutrient Content of Diets of
Iowa Children According to Serum Carotenoid Concentrati

Girls

Age in yrs.	No.	Group[a]	Blood carotene	Food energy cal.	Protein gm.	Calcium mg.	Iron mg.	Vitamin A value	Ascor aci mg
6	4	I	58	1821	53	768	8	4219	46
	3	II	240	1749	57	751	8	11868	63
7	5	I	66	2032	62	934	9	4348	62
	5	II	185	2099	67	1074	10	9040	97
8	2	I	60	2194	73	1258	9	4898	39
	4	II	197	2207	76	1354	11	7981	117
9	5	I	68	2269	60	717	9	3585	88
	6	II	171	2138	68	949	10	6621	83
10	1	I	65	2283	67	1018	10	3920	44
	1	II	367	2381	67	883	11	4640	108
11	4	I	55	2147	68	956	10	3649	67
	6	II	171	2117	71	970	10	6472	77

[a] Group — Serum Carotenoid Concentration

I — Minus 2 or 3 standard deviations

II — Plus 2 or 3 standard deviations

Table 63

n Daily Food Energy and Nutrient Content of Diets of
a Children According to Serum Carotenoid Concentrations

Girls

Food energy cal.	Protein gm.	Calcium mg.	Iron mg.	Vitamin A value	Ascorbic acid mg.	Thiamine mg.	Ribo-flavin mg.	Niacin mg.
1821	53	768	8	4219	46	0.8	1.3	10
1749	57	751	8	11868	63	0.8	1.7	10
2032	62	934	9	4348	62	1.0	1.7	11
2099	67	1074	10	9040	97	1.1	2.1	12
2194	73	1258	9	4898	39	1.0	2.2	11
2207	76	1354	11	7981	117	1.2	2.4	11
2269	60	717	9	3585	88	1.1	1.4	13
2138	68	949	10	6621	83	1.7	1.8	12
2283	67	1018	10	3920	44	1.0	2.0	15
2381	67	883	11	4640	108	1.8	1.7	10
2147	68	956	10	3649	67	1.0	1.7	10
2117	71	970	10	6472	77	1.1	1.8	12

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Table 63 (continued)

Age in yrs.	No.	Group[a]	Blood carotene	Food energy cal.	Protein gm.	Calcium mg.	Iron mg.	Vitamin A value	Ascor acid mg
12	9	I	57	2287	72	1025	11	5906	76
	10	II	151	2532	83	1192	12	11279	82
13	3	I	37	2378	62	684	10	8630	57
	4	II	153	2534	82	1067	12	6214	96
14	2	I	54	2549	71	848	13	4119	83
	2	II	154	2324	77	1226	13	15434	95
15	4	I	68	2705	80	964	11	4413	71
	3	II	132	2953	89	968	14	9552	135
16	2	I	48	2242	58	518	9	2109	82
	3	II	136	2348	73	889	12	6060	77
17	1	I	66	2218	68	904	9	2683	47
	2	II	182	2700	80	999	14	7887	77
18	1	I	91	2088	65	900	10	6523	43
	1	II	198	2468	80	1212	11	6540	155

Food energy cal.	Protein gm.	Calcium mg.	Iron mg.	Vitamin A value	Ascorbic acid mg.	Thiamine mg.	Ribo-flavin mg.	Niacin mg.
2287	72	1025	11	5906	76	1.1	1.8	13
2532	83	1192	12	11279	82	1.2	2.3	14
2378	62	684	10	8630	57	1.1	1.4	13
2534	82	1067	12	6214	96	1.4	2.0	15
2549	71	848	13	4119	83	1.3	1.6	13
2324	77	1226	13	15434	95	1.2	2.9	13
2705	80	964	11	4413	71	1.2	1.9	14
2953	89	968	14	9552	135	1.5	2.0	18
2242	58	518	9	2109	82	1.0	1.1	12
2348	73	889	12	6060	77	1.2	1.7	13
2218	68	904	9	2683	47	0.9	1.7	10
2700	80	999	14	7887	77	1.3	1.8	15
2088	65	900	10	6523	43	0.8	1.5	10
2468	80	1212	11	6540	155	1.3	2.3	14

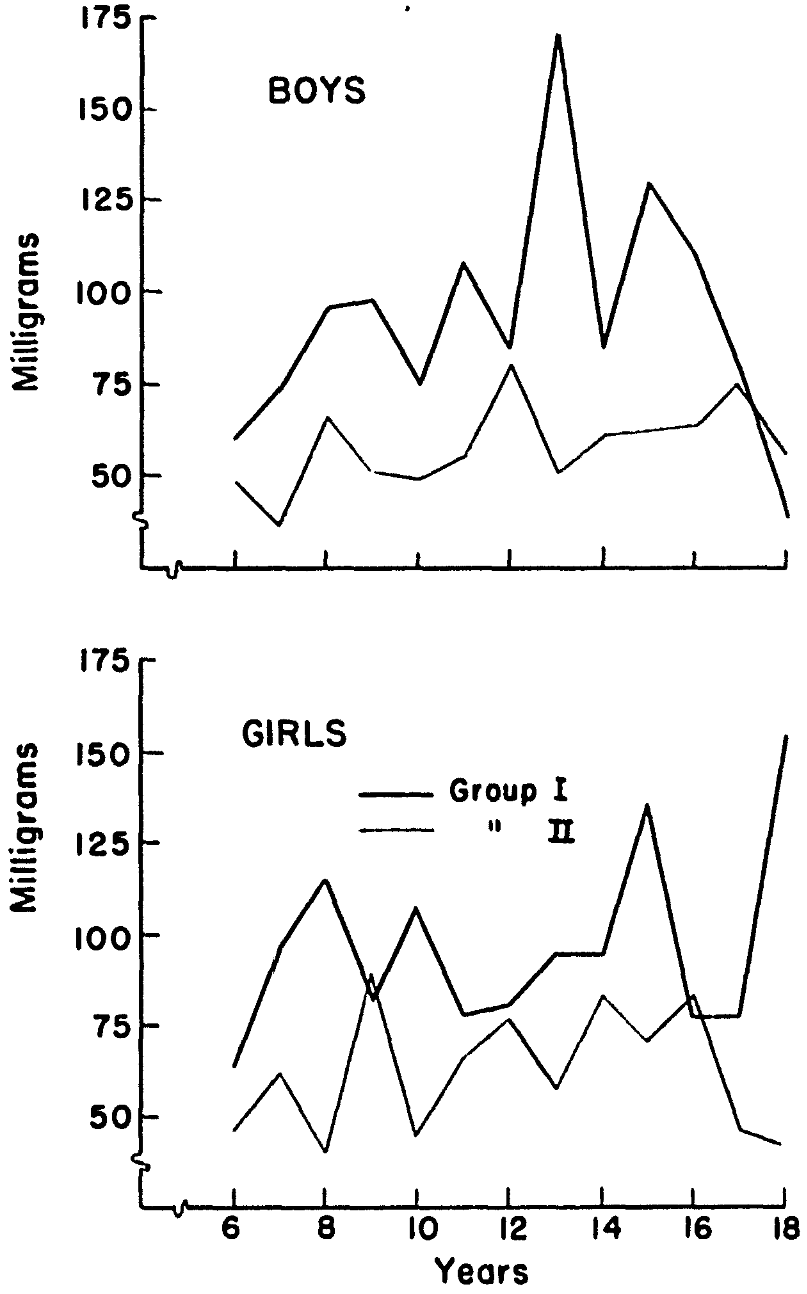

Fig. 33 Mean ascorbic acid content of the diets of Iowa children classified according to two groups of serum carotenoid concentrations

The girls with high serum concentration of carotenoids had diets that were richer in the B vitamins than had the girls with low concentration. The thiamine, riboflavin and niacin contents of the diets of the boys were not as consistently related to the concentration of serum carotenoids as they were for the girls.

From these data it appeared that the girls with the highest serum concentration of carotenoids tended to have diets that were richer in calories, protein, minerals and vitamins than the diets of the girls in the lowest serum carotenoid concentration group. The boys showed the same tendency, but the relationship was less consistent and regular.

Concentration of various blood constituents. The mean serum carotenoid concentration for each age-sex group are presented in Table 64. For the children with the highest, lowest and average concentrations of serum carotenoids, the serum ascorbic acid concentrations followed trends similar to those of the concentration of the serum carotenoids. For each group the tendency was for the mean of each age to decrease irregularly with age and the lowest serum ascorbic acid concentration was reached within four years of the minimum concentration of the serum carotenoids. It may be noted that the children with average

Table 64

Mean Serum Ascorbic Acid Concentrations of Iowa Children Classified According to Serum Carotenoid Concentrations

Groups[a]	I		II		III	
Age yr.	No.	Mg.%	No.	Mg.%	No.	Mg.%
			Boys			
6	3	1.04	3	0.52	15	0.97
7	3	0.59	4	0.97	18	0.89
8	5	0.47	6	1.29	23	0.83
9	5	0.67	5	1.50	21	1.07
10	6	0.50	6	0.96	22	0.84
11	3	0.50	3	1.37	20	0.97
12	10	0.50	12	0.80	43	0.78
13	5	0.26	3	1.17	18	0.74
14	3	0.27	2	1.28	12	0.52
15	0	--	1	0.81	12	0.47
16	2	0.21	1	0.90	10	0.60
17	1	1.00	2	0.48	4	0.55
18	1	0.58	1	1.10	8	0.38
			Girls			
6	3	0.70	2	1.10	19	0.98
7	5	0.95	5	1.16	21	1.04
8	2	0.56	4	1.74	19	0.82
9	5	0.52	6	1.27	26	0.95
10	1	0.41	1	1.67	26	1.00
11	4	0.67	6	0.81	25	0.68
12	9	0.55	10	0.94	43	0.75
13	3	0.40	4	0.67	18	0.47
14	2	0.30	2	0.92	9	0.57
15	4	0.49	3	0.46	8	0.46
16	2	0.30	3	0.84	9	0.70
17	1	0.58	2	1.10	7	1.05
18	1	0.58	1	1.69	5	0.95

[a]Group - Serum carotenoid concentrations
I Minus 2 or 3 standard deviations
II Plus 2 or 3 standard deviations
III Within ± 1 standard deviation.

serum carotenoid concentration reached the minima in both blood constituents at the same age.

In Table 65 are presented the mean alkaline phosphatase concentration of the children who have high, low or average serum carotenoid concentrations.

The boys with the highest concentration of serum carotenoids appeared to reach maturity a year later than the boys with the lowest concentration, as may be observed by maximum level in the serum alkaline phosphatase concentrations. The girls with the lowest serum concentration of carotenoid made the greatest increment in height between 9 to 10 years at which time there was a great increase in the concentration of serum alkaline phosphatase.

The boys with the highest serum concentration of carotenoids tended to have lower hemoglobin concentration in the blood than did the boys with the lowest concentration of serum carotenoids (see Figure 34). There were 9 age groups out of 13 at which the hemoglobin concentration of the boys with the highest carotenoid concentrations were lower than the ones for the boys with the lowest serum carotenoid concentrations. With the exception of two age groups the girls with the high carotenoid concentrations had higher hemoglobin concentrations in the blood than had the girls with low concentrations of serum carotenoids (see Table 66).

Table 65

Mean Alkaline Phosphatase Concentrations of Iowa Children Classified According to Serum Carotenoid Concentrations

Groups[a]	I		II		III	
Age yr.	No.	NP.U.[b]	No.	NP.U.	No.	NP.U.
			Boys			
6	3	2.89	3	4.37	15	4.77
7	2	5.73	4	6.03	18	4.95
8	5	5.10	6	5.96	23	5.28
9	5	5.93	5	5.66	21	5.72
10	6	4.13	6	4.79	22	5.02
11	3	4.65	2	4.48	20	4.97
12	10	6.19	12	6.33	43	6.37
13	3	5.71	3	7.84	18	6.03
14	3	5.00	2	4.48	12	6.51
15	0	--	1	3.72	12	5.65
16	2	5.08	1	3.97	10	4.09
17	1	1.62	2	3.11	4	4.66
18	1	2.19	1	2.80	8	2.42
			Girls			
6	4	5.52	3	6.58	19	4.67
7	5	5.25	5	4.81	21	4.87
8	2	5.77	4	4.45	19	4.84
9	5	4.13	6	7.55	26	5.02
10	1	7.46	1	3.84	26	5.72
11	3	5.56	6	4.74	25	6.37
12	9	4.88	10	5.45	43	5.49
13	3	3.81	4	2.58	18	4.77
14	2	2.28	2	3.66	9	3.17
15	4	2.46	3	5.09	8	1.82
16	2	2.12	3	1.70	9	2.10
17	1	1.22	2	2.10	7	1.47
18	1	.88	1	2.44	5	1.61

[a]Group - Serum carotenoid concentrations
I Minus 2 or 3 standard deviations
II Plus 2 or 3 standard deviations
III Within ± 1 standard deviation

[b]Nitrophenol units.

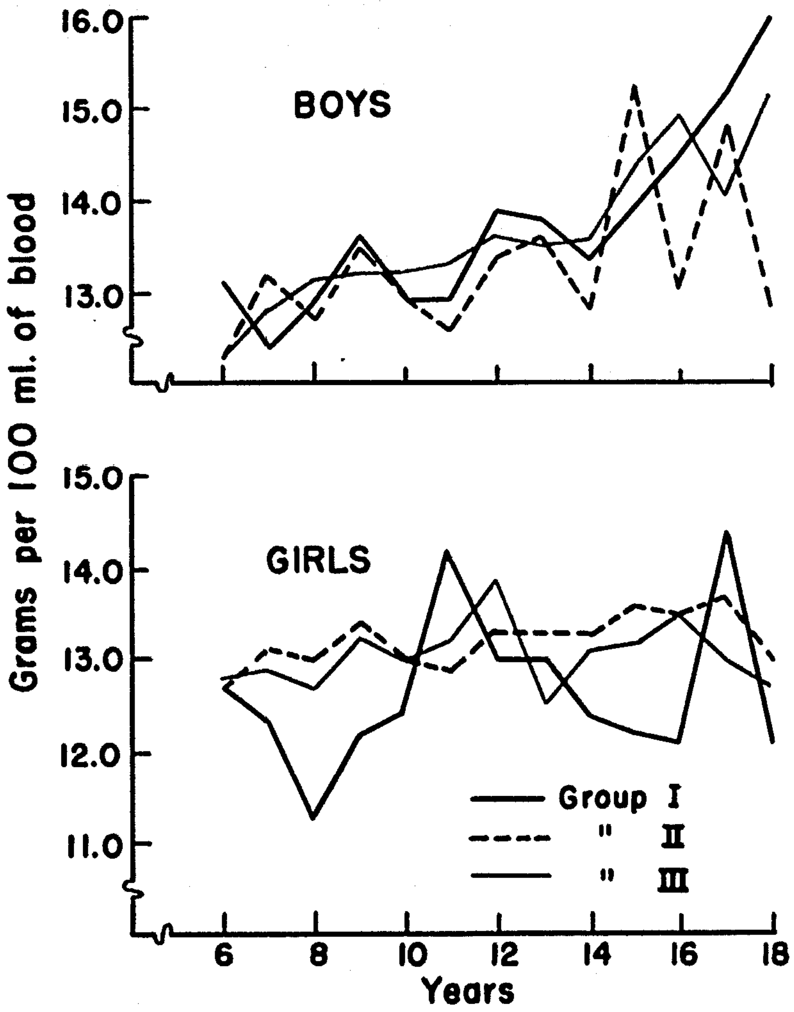

Fig. 34 Mean hemoglobin concentrations in blood of Iowa children classified according to three groups of serum carotenoid concentrations

Table 66

Mean Hemoglobin Concentration in Blood of Iowa Children Classified According to Serum Carotenoid Concentrations

Groups[a]	I		II		III	
Age yr.	No.	Gm.%	No.	Gm.%	No.	Gm.%
			Boys			
6	3	13.1	3	12.3	15	12.3
7	3	12.4	4	13.2	18	12.8
8	5	12.9	6	12.7	23	13.1
9	5	13.6	5	13.5	21	13.2
10	6	12.9	6	12.9	22	13.2
11	3	12.9	3	12.6	20	13.3
12	10	13.9	11	13.4	43	13.6
13	4	13.8	3	13.6	18	13.5
14	3	13.4	2	12.8	12	13.6
15	0	--	1	15.2	12	14.4
16	2	14.5	1	13.0	10	14.9
17	1	15.2	2	14.8	4	14.0
18	1	16.0	1	12.8	8	15.2
			Girls			
6	3	12.7	3	12.7	19	12.8
7	5	12.3	4	13.1	21	12.9
8	2	11.2	4	13.0	19	12.7
9	5	12.2	6	13.4	26	13.3
10	1	12.4	1	13.0	26	13.0
11	4	14.2	6	12.9	25	13.2
12	8	13.0	10	13.3	43	13.9
13	3	13.0	4	13.3	18	12.5
14	2	12.4	2	13.3	9	13.1
15	4	12.2	3	13.6	8	13.2
16	2	12.1	3	13.5	9	13.5
17	1	14.4	2	13.7	7	13.0
18	1	12.1	1	13.0	5	12.7

[a]Group - Serum carotenoid concentrations
I Minus 2 or 3 standard deviations
II Plus 2 or 3 standard deviations
III Within ± 1 standard deviation.

Summary

1. For Iowa children the mean serum concentrations of carotenoids tended to decrease irregularly with age until they reached the minimum at 15 years for boys and 13 years for girls. The reduction of the serum concentration with age may indicate that the conversion of the carotenoids to vitamin A was rapid during the changes of puberty.

2. For boys the serum carotenoid concentrations were positively correlated with the intake of carotene-rich foods and negatively correlated with age.

3. The boys with the highest serum carotenoid concentration from 6 to 12 years were lighter in weight but taller than the boys with low serum carotenoid concentrations. The older boys and girls showed no similar relationship.

4. The children with the highest serum carotenoid concentration tended to have diets higher in vitamin A value than the children with the lowest serum carotenoid concentration.

5. The girls with high serum carotenoid concentrations tended to have diets richer in calories, protein, vitamins and minerals than the girls with low serum carotenoid concentrations. The boys did not have as conspicuous a

relationship between serum concentration and nutrient intake as did the girls.

6. The children with high serum carotenoid concentrations had high serum ascorbic acid concentrations, and the children with lowest concentrations of serum carotenoids had low concentrations of serum ascorbic acid. The children with average concentrations of serum carotenoids had intermediate values for serum ascorbic acid concentrations.

7. The boys with the highest serum carotenoid concentrations seemed to reach maturity a year later than the boys with low concentrations, as noted by the peak level in the serum alkaline phosphatase. The girls with the lowest serum carotenoid concentration exhibited a great rise in serum alkaline phosphatase at 9 to 10 years.

8. The girls with the lowest serum concentrations of carotenoids tended to have lower hemoglobin concentrations in the blood than did the girls with the highest concentration of serum carotenoids. The boys with the lowest concentration of serum carotenoids tended to have higher hemoglobin concentrations in the blood than did the boys with the highest concentrations of serum carotenoids.

Serum Alkaline Phosphatase Concentrations of Iowa Children

Alkaline phosphatase is an enzyme which is widely distributed in mammalian cells. This enzyme is more concentrated per unit weight in the kidney, liver and intestines than in the bone. The greater part of the phosphatase in the blood comes from the bone because of the large proportion of bone tissue.

Robison (1923) discovered that a young rapidly growing bone was very rich in the enzyme. He noted that long bones from a rachitic rat incubated at 37° in a solution of calcium hexomonophosphate or glycerophosphate at a pH 8.4 to 9.4 were able to deposite "fresh calcium phosphate in the zone of provisional calcification, and particularly in the region of hypertrophic cartilige cells." The observations from his _in vitro_ experiments led Robison to conclude that phosphatase played an important role in the calcification of bone.

Kay (1930) observed a distinct rise in the serum alkaline phosphatase concentrations in individuals who had disturbances either in bone formation or bone maintenance such as occur in osteitis deformans, generalized osteitis fibrosa, osteomalacia and rickets. The increase in the phosphatase concentrations correlated roughly with the severity of the diseases.

Talbot (1941) in his studies of the functions of the thyroid gland found that an exceptionally low phosphatase concentration in infancy may be associated with cretinism. He also observed that children who had a tendency toward a low metabolic rate had a lower alkaline phosphatase concentration than children whose basal metabolic rates were within the normal range.

Mean serum alkaline phosphatase concentration of total sample of Iowa children

In the investigation of the nutritional status of Iowa school children the serum alkaline phosphatase concentration was measured on 337 boys and 336 girls. This index of nutritional status was made for the sample of children who attended the urban elementary schools and the small town elementary, junior and senior high schools.

In Table 67 the means, standard deviation, standard error of the mean and the range for all the boys and girls of each age and sex have been tabulated. For both sexes the range became more narrow each year in the last part of the teen years (16 to 18).

Table 67

Mean Serum Alkaline Phosphatase Concentrations of Iowa Children

Age yr.	No.	Mean NP.U.[a]	Standard deviation NP.U.	Standard error NP.U.	Range NP.U.
			Boys		
6	22	4.46	1.46	0.31	2.26 - 7.82
7	28	5.16	1.32	0.25	3.42 - 8.01
8	37	5.37	1.57	0.26	2.78 - 9.20
9	35	5.75	1.93	0.33	3.05 - 12.08
10	35	4.83	1.69	0.29	1.83 - 9.32
11	26	4.90	1.30	0.26	2.70 - 8.24
12	65	6.05	2.06	0.26	2.88 - 13.33
13	26	6.42	2.16	0.42	2.62 - 12.02
14	17	6.01	2.18	0.53	2.86 - 11.99
15	14	5.52	2.73	0.73	1.89 - 11.50
16	15	4.21	1.80	0.46	2.16 - 8.41
17	7	3.78	1.30	0.49	1.62 - 5.54
18	10	2.44	0.74	0.24	1.59 - 4.04
			Girls		
6	27	5.01	1.62	0.31	2.25 - 8.78
7	32	4.92	1.79	0.32	2.34 - 9.30
8	25	4.85	1.71	0.34	2.78 - 9.13
9	39	5.30	1.99	0.32	2.55 - 12.04
10	29	5.72	2.09	0.39	2.22 - 10.65
11	33	6.01	3.56	0.62	2.25 - 22.12
12	65	5.40	1.91	0.24	1.68 - 11.21
13	25	4.30	1.98	0.40	1.08 - 9.13
14	14	3.11	1.54	0.41	1.18 - 6.23
15	15	2.64	1.72	0.44	1.30 - 6.69
16	15	2.02	0.66	0.17	1.24 - 2.87
17	10	1.57	0.59	0.19	0.89 - 2.65
18	7	1.62	0.55	0.21	0.88 - 2.44

[a]Nitrophenol units.

It was noted from standard deviations and ranges, that the values for the alkaline phosphatase concentrations varied widely about the mean. The standard deviations were largest from 12 to 15 years for the boys and at 11 years for the girls.

Wide variability in serum alkaline phosphatase concentration was noted in other studies. Bodansky (1934) obtained a range of 2.8 to 7.8 nitrophenal units from a study of 27 children 2 to 15 years. This study included so few subjects that the variation of concentrations at each age could not be observed. Talbot (1941) noted a similar range in his study of 70 normal children 2 to 10 years of age.

Adamson _et al_. (1945) claimed that a range of 2 to 8 nitrophenol units can be expected from normal girls under 13 years and boys under 15 years of age. They found this range in the study of some Newfoundland children who appeared to have no symptoms of vitamin D or calcium deficiency.

The mean serum alkaline phosphatase concentrations obtained by Harrison _et al_. (1948) on 223 Michigan children, by Clark and Beck (1950) on 401 (part of the whole group) Ohio children, by Bessey and Lowry (1947) on 1200 New York school children, have been charted in Figure 35 along with the Iowa data. Except for the study by Bessey and Lowry,

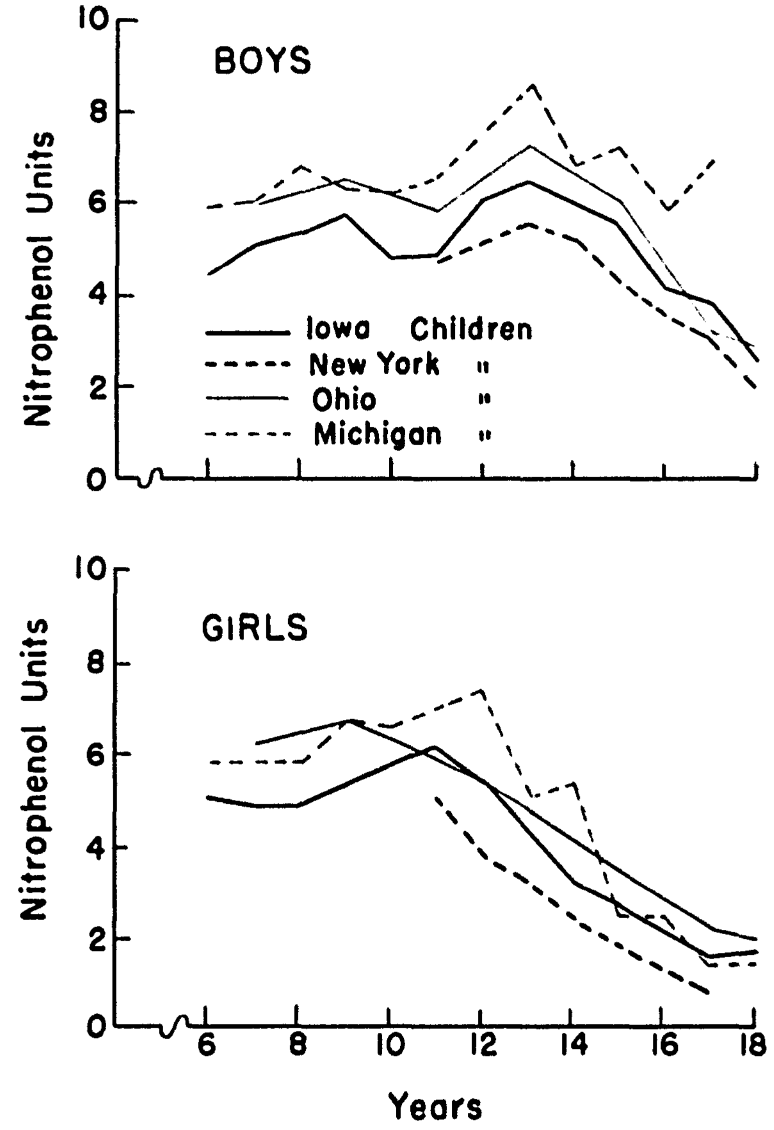

Fig. 35 Comparison of mean serum alkaline phosphatase concentrations of selected groups of children

the age range was 6 to 18 years for boys and girls. In the four studies the same method was used to determine the serum alkaline phosphatase concentrations.

The concentrations observed by Harrison et al. (1948) tended to be the highest for both the girls and boys. The observations made by Clark and Beck (1950) were next, and the lowest values were obtained by Bessey and Lowry (1947) on the New York school children. The serum alkaline phosphatase concentrations of Iowa children tended to be intermediate between the values obtained by Clark and Beck and Bessey and Lowry.

Some of the differences found in these four studies may be due to the character of the subjects. The children observed by Harrison et al. (1948) came from five different institutions. They were mainly from broken or underprivileged homes. The observations of Clark and Beck were a part of a longitudinal study on a group of Ohio children who came primarily from stable homes, probably from a higher socioeconomic level than that of the Michigan children. Bessey and Lowry selected schools which they believed to be representative of different socioeconomic level; therefore, these investigators chose schools in the rural area, in small towns and in congested urban areas in and about New York City.

The Iowa children were randomly chosen from the school children who attended the city elementary schools and those who attended the small town elementary and high schools. It is the only study where an effort was made to obtain results that were representative of a large population of children. The means for each age-sex group may be more representative of the expected alkaline phosphatase concentrations for a group of children.

There was a marked similarity of trends in the curves which described the mean alkaline phosphatase concentrations of the four groups of children at the various ages, especially for the boys. The serum alkaline phosphatase concentrations rose to a high concentration, then they started to fall so that by the end of puberty they were approaching the concentrations often observed in adults. The serum alkaline phosphatase concentrations for Iowa boys were highest at 12 to 14 years; they attained a peak at 13 years. The high concentrations for Iowa girls extended from 10 to 12 years, with a peak at 11 years. These peaks occurred slightly in advance of the average ages of puberty, 15 years for boys and 13 years for girls (Watson and Lowrey, 1951).

Mulay and Hurwitz (1938) noted high serum alkaline phosphatase concentrations in his study of 272 children just before puberty. Afterwards there was a decline to adult levels. For the individual the decline maybe rapid or gradual and extend to 25 years. Age group averages indicated that in general the decrease from the peak to adult concentrations was gradual.

For boys the mean of serum alkaline phosphtase concentrations reached a peak at 13 years in each of the four studies. In contrast the peak was not reached at a uniform age by the girls in the different studies. The Michigan girls reached the peak a year later, and the Ohio girls two years earlier than the Iowa girls. The age at which the highest values for serum alkaline phosphatase concentrations are attained, is determined primarily by the rate of maturation. The differences in the ages when these groups obtained the highest mean concentrations may be due to the various rates of maturation, which in turn may be influenced by dietary and other environmental conditions.

The depression observed in mean serum alkaline phosphatase concentrations of Iowa boys at the ages of 10 to 11 years was noted to some degree in the data of the other three studies. In the Iowa data this observation may not be merely a sampling peculiarity but a physiological depression of the enzyme in the serum just before the increase which accompanied the spurt of growth at puberty. During the time that these lowered mean concentrations prevailed the Iowa boys were making only small increments in height and weight. It was a period when growth was very slow.

After the peak had been reached, the mean serum alkaline phosphatase concentrations as a whole tended to be lower for the girls than for the boys.

Study of three groups of boys and girls classified according to serum alkaline phosphatase concentrations

In order to observe the differences that existed between the children who had high, low or average serum alkaline phosphatase concentrations, each age-sex group was divided into three groups according to the mean and standard deviation. In Group I were all the children who had serum alkaline phosphatase concentration in the second or third standard deviation below the mean; in Group II, those in the second and third standard deviation above the mean; in Group III, those within plus or minus one standard deviation.

In Table 68 are presented the mean serum alkaline phosphatase concentrations of the three groups by age and sex. The means of the serum alkaline phosphatase concentrations of the girls and boys with the lowest levels (Group I)

Table 68

Mean Serum Alkaline Phosphatase Concentrations of Iowa Children Classified According to Level of Serum Alkaline Phosphatase Concentrations

Groups[a]	I		II		III		All	
Age yr.	No.	Mean NP.U.[b]	No.	Mean NP.U.	No.	Mean NP.U.	No.	Mean NP.U.
				Boys				
6	3	2.71	5	6.43	14	4.13	22	4.46
7	7	3.57	6	7.32	19	4.73	28	5.16
8	6	3.37	6	8.07	25	5.20	37	5.37
9	3	3.31	3	10.42	29	5.52	35	5.75
10	6	2.70	5	7.89	24	4.72	35	4.83
11	4	3.20	4	7.16	18	4.77	26	4.90
12	8	3.43	9	9.79	48	5.79	65	6.05
13	5	3.25	2	11.32	19	6.74	26	6.42
14	2	3.32	1	11.99	14	5.96	17	6.01
15	1	1.89	3	9.60	10	4.65	14	5.52
16	3	2.22	2	7.62	10	4.13	15	4.21
17	1	1.62	1	5.54	5	3.86	7	3.78
18	1	1.59	1	4.04	8	2.35	10	2.44
				Girls				
6	6	2.82	5	7.33	16	5.10	27	5.01
7	4	2.52	5	7.91	23	4.69	32	4.92
8	5	2.94	3	8.39	17	4.79	25	4.85
9	5	2.88	7	8.51	27	4.91	39	5.30
10	6	2.86	6	8.59	17	5.71	29	5.72
11	1	2.25	3	14.80	29	5.22	33	6.11
12	7	2.65	10	8.72	48	5.10	65	5.40
13	3	1.85	3	8.58	19	4.01	25	4.30
14	1	1.18	3	5.54	10	2.57	14	3.11
15	0	--	2	6.66	13	2.02	15	2.64
16	2	1.29	2	3.21	11	1.94	15	2.02
17	1	0.89	2	2.48	7	1.41	10	1.57
18	1	0.88	2	2.33	4	1.46	7	1.62

[a]Group	Serum alkaline phosphatase concentrations
I	Minus 2 or 3 standard deviations
II	Plus 2 or 3 standard deviations
III	Within ± 1 standard deviation

[b]Nitrophenol units.

failed to show the fluctuations and the peak characteristic of the other two groups (see Figure 36). The concentrations of the girls after 10 years exhibited a slow gradual decrease but the values for the boys in this group were strikingly similar at all ages. According to Talbot (1941) low values may occur in children who have a tendency toward hypothyroidism.

The mean serum alkaline phosphatase concentrations of the boys and girls in Group II (those with high levels) exhibited a definite rise at 14 years for boys and 11 years for girls. The decline from the high peak to the adult levels was rapid. The descent was more irregular for the girls than for the boys. Very high alkaline phosphatase concentrations may denote bone disorders. The values found in this group were probably not within the pathological limits.

The children with serum alkaline phosphatase concentrations within plus or minus one standard deviation of the mean had a definite increase in serum concentration of this substance at puberty. It appeared at 13 years of age for the boys and at 10 years for the girls, but the decrease toward adult levels was not definite for girls until 12. The boys and girls with average concentrations of serum alkaline phosphatase (Group III) reached the maximum

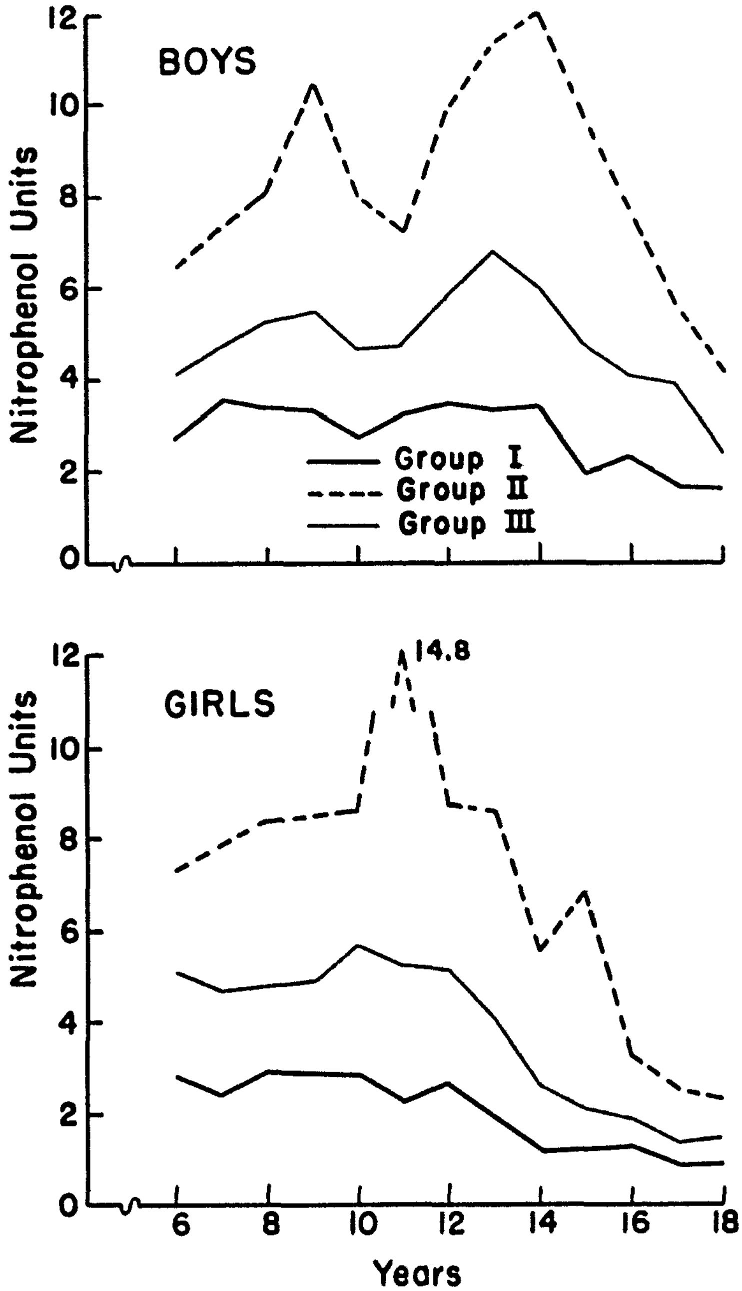

Fig. 36 Mean serum alkaline phosphatase concentration of Iowa children classified according to level of serum alkaline phosphatase concentrations

concentration a year earlier than the children in Group II. The high concentrations of serum alkaline phosphatase around the period of puberty would seem to indicate delayed maturation.

Physical status. There was no outstanding difference between the mean heights of the three groups of boys. This finding was not in accordance with Clark and Beck (1950) who reported that the alkaline phosphatase activity is associated with yearly increments of linear growth (see Table 69). The heights of the girls with the highest and average serum alkaline phosphatase concentrations were similar (Groups II and III). The girls with lowest concentrations (Group I) tended to have mean heights that were below the heights for the girls in Groups II and III from 6 through 10 years of age. After 10 years the heights of the girls in the three groups fluctuated, but at some ages the heights of the girls with lowest alkaline phosphatase concentration tended to be greater than the heights of the girls in the other two groups.

From 6 to 10 years of age the boys with the highest concentrations of serum alkaline phosphatase were heavier than the boys with the lowest concentrations. It may indicate that the boys in Group II were maturing more rapidly than

Table 69

Mean Heights of Iowa Children Classified According to Serum Alkaline Phosphatase Concentrations

Groups[a]	I		II		III	
Age yr.	No.	Cm.	No.	Cm.	No.	Cm.
			Boys			
6	3	122	5	118	12	117
7	3	125	6	126	19	124
8	6	130	6	133	25	131
9	3	138	3	135	29	135
10	6	139	5	143	24	139
11	4	152	4	142	18	145
12	8	148	9	151	48	148
13	5	159	2	158	19	158
14	2	158	1	161	14	158
15	1	176	3	169	10	171
16	3	167	2	174	10	170
17	1	169	1	170	5	176
18	1	165	1	168	7	174
			Girls			
6	6	117	5	115	16	119
7	4	116	5	125	23	124
8	5	127	3	127	18	128
9	5	133	7	137	27	132
10	6	136	6	144	17	142
11	1	154	3	146	29	147
12	7	156	10	150	51	151
13	3	147	3	156	19	154
14	1	164	3	156	10	157
15	0	--	2	158	13	162
16	2	174	2	172	11	162
17	1	156	2	160	7	162
18	1	160	2	166	4	165

[a]Group	Serum alkaline phosphatase concentrations
I	Minus 2 or 3 standard deviations
II	Plus 2 or 3 standard deviations
III	Within ± standard deviations

the boys in the other two groups, if gain in weight is considered indicative of rate of maturation (see Figure 37).

After 10 years the weights of boys in Groups I and II fluctuated together above or below the means of weight of the boys with average serum alkaline phosphatase concentration.

The boys with average concentrations of serum alkaline phosphatase made more regular increments in weight from year to year than the boys with serum alkaline phosphatase concentration of extreme values (see Table 70).

From 6 through 11 years the girls with highest serum alkaline phosphatase were heavier than the girls with lowest serum concentrations. After 11 years the girls with the lowest concentrations tended to be the heaviest.

The girls from 6 to 10 or 11 years with the highest concentrations (Group II) appeared to gain weight at a faster rate than the girls with the lowest concentrations (Group I) to the time that the girls in Group II attained the maximum concentrations. Afterwards, the girls in Group I gained weight more rapidly than Group II. By the sixteenth year both groups weighed about the same. The girls and boys with average serum alkaline phosphatase concentrations made regular yearly increments in height and weight throughout the age range.

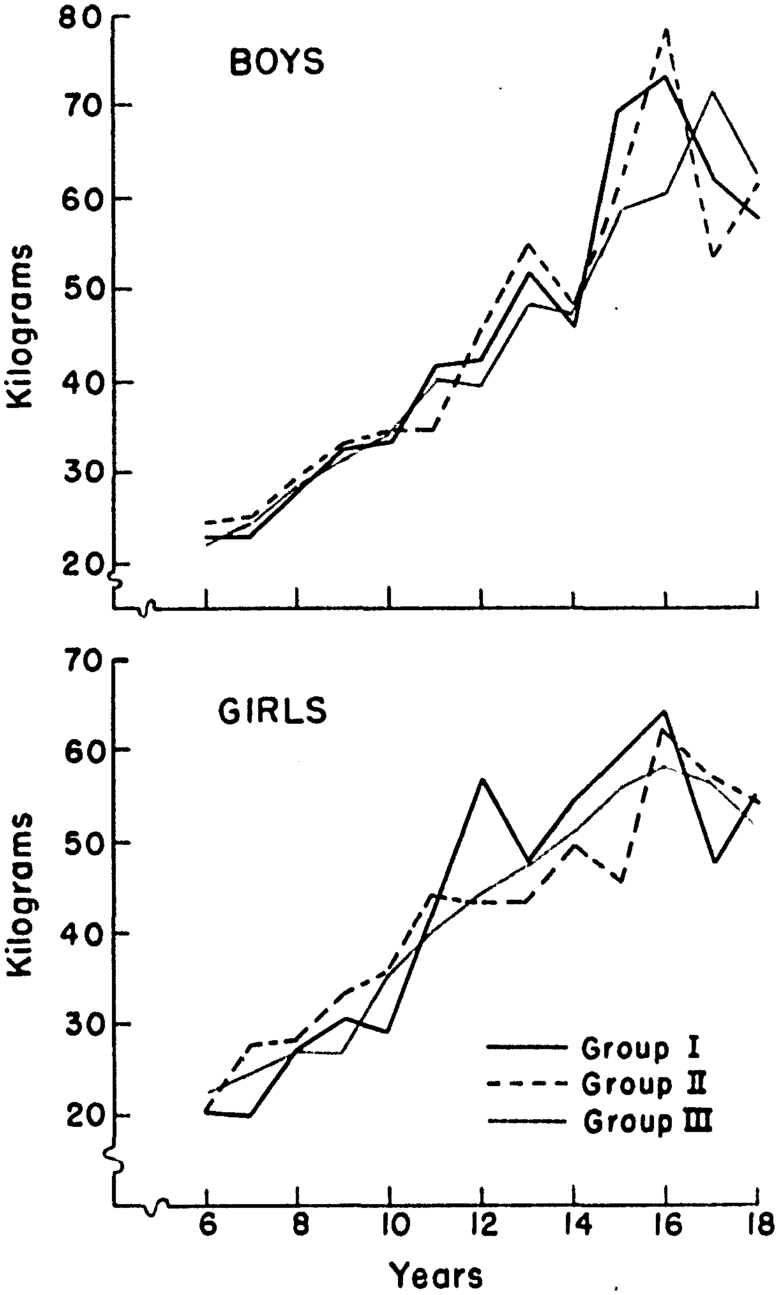

Fig.37 Mean weights of Iowa children classified according to serum alkaline phosphatase concentration

Table 70

Mean Weights of Iowa Children Classified According to Serum Alkaline Phosphatase Concentrations

Groups[a]	I		II		III	
Age yr.	No.	Kg.	No.	Kg.	No.	Kg.
			Boys			
6	3	23.1	5	24.4	12	22.3
7	3	23.5	6	25.3	19	24.7
8	6	28.4	6	29.6	25	28.7
9	3	32.8	3	33.1	29	31.6
10	6	33.5	5	34.5	24	34.1
11	4	41.6	4	34.3	18	40.2
12	8	42.2	9	45.4	48	39.3
13	5	51.8	2	54.4	19	48.3
14	2	46.0	1	47.0	14	48.5
15	1	69.2	3	61.1	10	58.9
16	3	73.3	2	78.2	10	60.7
17	1	61.9	1	53.8	5	71.6
18	1	57.8	1	62.1	7	61.0
			Girls			
6	6	20.6	5	20.2	16	22.8
7	4	20.0	5	27.8	23	24.7
8	5	27.3	3	28.2	18	27.0
9	5	30.5	7	33.6	27	27.0
10	6	29.5	6	35.7	17	36.3
11	1	44.0	3	44.3	29	40.2
12	7	56.6	10	43.2	51	44.3
13	3	47.6	3	43.5	19	47.6
14	1	54.9	3	49.7	10	51.4
15	0	--	2	45.8	13	56.0
16	2	64.4	2	62.7	11	58.4
17	1	47.6	2	56.7	7	57.1
18	1	55.1	2	54.6	4	51.3

[a]Group	Serum alkaline phosphatase concentrations
I	Minus 2 or 3 standard deviations
II	Plus 2 or 3 standard deviations
III	Within ± standard deviations

The trends of the relationship between the level of serum alkaline phosphatase and the developmental levels of the three groups and for both sexes were similar to those observed for weights (see Table 71).

Nutrient intake. In Table 72 are presented the mean food energy, protein, calcium, iron, vitamin A and ascorbic acid content of the diets of the girls and boys in the lowest, highest and average serum concentration of alkaline phosphatase groups. The relationship between the level of serum alkaline phosphatase and the mean daily intakes of the various nutrients exhibited no particular trend. Bessey and Lowry (1946) found no significant changes in the phosphatase levels of two subjects that could be attributed to fasting, a high protein meal or a high fat meal.

Concentrations of the various blood constituents. The boys from 10 through 14 years had serum ascorbic acid concentrations that followed the direction of the three groups of serum alkaline phosphatase. That is, the boys of these ages with the highest concentrations in alkaline phosphatase had high serum ascorbic acid concentration; low phosphatase had lowe serum ascorbic acid concentrations. At the other ages the boys in the three groups showed no consistent relationship between the concentrations of serum alkaline

Table 71

Mean Developmental Levels of Iowa Children Classified According to Serum Alkaline Phosphatase Concentrations

Groups[a]	I		II		III	
Age yr.	No.	D.L.[b]	No.	D.L.[b]	No.	D.L.[b]
			Boys			
6	3	56	5	60	12	51
7	3	60	6	61	19	66
8	6	77	6	82	25	78
9	3	93	3	92	29	88
10	6	96	5	99	24	97
11	4	119	4	97	18	112
12	8	117	9	125	48	112
13	5	140	2	146	19	133
14	2	129	1	134	14	134
15	1	172	3	160	10	156
16	3	176	2	193	10	158
17	1	161	1	148	5	182
18	1	154	1	161	7	167
			Girls			
6	6	44	5	43	16	53
7	4	60	5	71	23	63
8	5	73	3	75	18	71
9	5	83	7	97	27	76
10	6	83	6	103	17	102
11	1	125	3	123	29	113
12	7	145	10	122	51	123
13	3	131	3	127	19	131
14	1	148	3	137	10	140
15	0	--	2	130	13	149
16	2	164	2	158	11	168
17	1	134	2	150	7	150
18	1	148	2	149	4	142

[a]Group — Serum alkaline phosphatase concentrations
I — Minus 2 or 3 standard deviations
II — Plus 2 or 3 standard deviations
III — Within ± standard deviation

[b]Developmental levels of Wetzel's Grid.

Table 72

Mean Daily Food Energy and Nutrient Value of Diets of Iowa Children Classified According to Serum Alkaline Phosphatase Concentrations

Age yrs.	No.	Groups[a]	Age mo.	Food energy cal.	Protein gm.	Calcium mg.	Iron mg.	Vit. A value I.U.	Ascorbic acid mg.
				Boys					
6	3	I	82	2476	70	1163	9	4123	66
	5	II	76	2325	78	1341	10	4843	96
	12	III	79	2246	68	1087	10	6813	75
7	3	I	93	2098	69	1176	9	6559	70
	6	II	90	2099	67	1074	9	5164	54
	19	III	89	2062	64	1015	10	5660	66
8	6	I	101	2197	70	1108	10	5570	79
	6	II	101	1967	62	913	9	5730	60
	25	III	101	2231	71	1146	10	6751	76
9	3	I	114	2532	81	1394	11	7742	80
	3	II	116	2472	77	1127	12	5911	62
	29	III	113	2359	73	1072	11	8862	84

[a]Group	Serum alkaline phosphatase concentrations
I	Minus 2 or 3 standard deviations
II	Plus 2 or 3 standard deviations
III	Within ± 1 standard deviations

Table 72 (Cont'd)

Age yrs.	No.	Groups	Age mo.	Food energy cal.	Protein gm.	Calcium mg.	Iron mg.	Vit. A value I.U.	Ascorbic acid mg.
10	6	I	127	2392	77	1011	11	6762	70
	5	II	127	2564	82	1048	12	8126	81
	24	III	125	2414	75	1077	11	8743	72
11	4	I	138	2974	93	1026	14	5974	80
	4	II	140	2494	76	1222	11	6152	88
	18	III	137	2557	81	1182	11	6031	79
12	8	I	148	2525	83	1017	13	6661	98
	9	II	148	3078	96	1260	14	9654	96
	50	III	148	2741	86	1172	13	8193	81
13	5	I	162	2986	87	1133	13	6884	81
	2	II	159	3484	101	1398	15	16204	179
	19	III	161	2841	89	1251	13	8815	82
14	2	I	174	3125	98	1170	16	8718	87
	1	II	172	3806	112	1630	16	18707	111
	14	III	174	2872	83	1084	12	7380	88
15	1	I	186	3679	104	1580	13	5506	60
	3	II	185	3626	100	1207	17	12627	109
	10	III	186	2917	90	1239	13	7430	81
16	3	I	199	3348	103	1571	16	17808	136
	2	II	194	3463	94	1004	15	3940	75
	10	III	197	3299	95	1397	14	9048	119

Table 72 (Cont'd)

Age yrs.	No.	Groups	Age mo.	Food energy cal.	Protein gm.	Calcium mg.	Iron mg.	Vit. A value I.U.	Ascorbic acid mg.
17	1	I	204	3898	132	2422	16	7367	77
	1	II	204	3440	114	1742	16	6726	126
	4	III	208	3510	104	1539	14	5764	66
18	1	I	219	3066	88	1211	13	6725	75
	1	II	224	2814	86	779	12	7501	32
	7	III	222	3425	111	1273	16	10084	91
				Girls					
6	6	I	78	1807	53	729	9	3711	53
	5	II	76	1871	58	803	9	9477	74
	16	III	78	1959	62	1087	9	6455	66
7	4	I	88	2090	56	807	8	3246	92
	5	II	90	1953	63	945	9	6228	52
	23	III	89	1986	62	920	9	6177	71
8	5	I	102	2182	68	1083	9	6496	79
	3	II	99	2129	63	936	9	5667	67
	18	III	101	2045	68	1090	9	7798	82
9	5	I	115	2412	73	1031	11	7041	89
	7	II	113	2379	73	1022	12	8432	87
	27	III	114	2301	71	1015	10	7405	80
10	6	I	125	2409	77	1030	11	6924	102
	6	II	126	2340	73	1102	11	11571	81
	17	III	126	2228	70	989	11	7953	84

Table 72 (Cont'd)

Age yrs.	No.	Groups	Age mo.	Food energy cal.	Protein gm.	Calcium mg.	Iron mg.	Vit. A value I.U.	Ascorbic acid mg.
11	1	I	141	2616	75	1113	11	13765	110
	3	II	136	2081	60	934	8	4044	60
	29	III	137	2276	72	1024	10	6319	72
12	7	I	151	2510	74	922	15	8750	92
	10	II	148	2547	79	1083	12	9276	69
	51	III	148	2562	80	1098	12	8058	81
13	3	I	161	2153	64	959	9	4369	68
	3	II	163	1953	59	756	10	7722	40
	19	III	161	2418	71	910	11	6050	74
14	1	I	177	2191	64	608	13	3304	85
	3	II	173	2052	65	797	10	5607	96
	10	III	173	2444	79	1117	12	8115	76
15	0	I	--	--	--	--	--	--	--
	2	II	185	3034	89	869	13	4296	107
	13	III	186	2687	79	944	12	7740	81
16	2	I	198	2196	70	938	9	5123	89
	2	II	195	1862	55	579	10	8888	72
	11	III	198	2156	68	815	10	4557	68
17	1	I	208	2909	81	1080	15	15911	75
	2	II	206	1922	63	1036	9	4926	92
	7	III	210	1980	63	701	10	6655	73

Table 72 (Cont'd)

Age yrs.	No.	Groups	Age mo.	Food energy cal.	Protein gm.	Calcium mg.	Iron mg.	Vit. A value I.U.	Ascorbic acid mg.
18	1	I	217	2088	65	900	10	6533	43
	2	II	219	1961	62	824	10	4458	125
	4	III	222	2698	86	973	12	8345	91

phosphatase and serum ascorbic acid. When girls with extreme phosphatase levels were omitted, the decrease of ascorbic acid concentrations with ages from 6 to 15 years occurred in a fairly steady manner. For the other two groups the trend was evident, but fluctuated (see Table 73).

During the ages 10 to 14 years the boys and the girls, except the girls in Group II, had ascorbic acid intakes above the allowances or within 10 milligrams of the allowances. Yet they had serum ascorbic acid concentrations that decreased to 0.4 milligram per cent. At this time serum alkaline phosphatase concentrations of the boys were rising, and of the girls were descending. It appeared that the boys were building osteoid tissue and the girls were accumulating soft tissue; in both growth processes ascorbic acid has important functional roles.

The mean concentration of serum carotenoids for both the boys and girls in the three groups fluctuated throughout the age range (see Table 74). The girls and boys with average serum alkaline phosphatase (Group III) exhibited less fluctuation than did the other two groups. The concentrations of the serum carotenoids of boys in the three groups decreased to a minimum at 15 years. This low concentration appeared one to three years after the group had

Table 73

Mean Serum Ascorbic Acid Concentrations of Iowa Children Classified According to Level of Serum Alkaline Phosphatase Concentrations

Groups[a]	I		II		III	
Age yr.	No.	Mg.	No.	Mg.	No.	Mg.
			Boys			
6	3	1.06	5	1.21	13	0.76
7	3	0.80	6	1.08	17	0.81
8	6	0.90	6	0.68	25	0.89
9	3	1.15	3	0.95	29	1.07
10	6	0.71	5	0.93	21	0.88
11	4	0.71	4	1.22	16	0.84
12	8	0.77	9	0.88	47	0.68
13	5	0.61	2	1.10	20	0.68
14	2	0.40	1	0.68	14	0.58
15	1	0.52	3	0.38	10	0.53
16	3	0.82	2	0.16	10	0.56
17	1	1.00	1	0.94	5	0.45
18	1	0.28	1	0.19	8	0.54
			Girls			
6	6	.97	5	1.31	13	1.02
7	4	1.14	5	1.02	22	1.04
8	5	0.71	3	0.90	17	1.02
9	5	0.96	7	1.15	25	0.98
10	6	1.12	6	0.68	16	1.12
11	1	1.64	3	0.67	30	0.68
12	7	0.78	10	0.92	45	0.73
13	3	0.51	3	0.30	19	0.52
14	1	0.41	3	1.14	9	0.55
15	0	--	2	0.34	13	0.48
16	2	0.58	2	0.61	10	0.77
17	1	0.22	2	1.45	7	1.00
18	1	0.58	2	1.68	4	0.78

[a]Group	Serum alkaline phosphatase concentrations
I	Minus 2 or 3 standard deviations
II	Plus 2 or 3 standard deviations
III	Within ± 1 standard deviations

Table 74

Mean Serum Carotenoid Concentrations of Iowa Children Classified According to Serum Alkaline Phosphatase Concentrations

Groups[a]	I		II		III	
Age yr.	No.	Mcg.	No.	Mcg.	No.	Mcg.
			Boys			
6	3	67	4	114	14	112
7	3	118	6	134	16	123
8	6	111	5	125	23	116
9	3	114	3	98	25	110
10	6	93	5	131	23	130
11	4	122	3	136	19	112
12	8	105	8	85	49	109
13	4	78	2	152	20	105
14	2	98	1	93	14	87
15	1	44	3	48	9	84
16	3	78	2	54	8	92
17	1	52	1	110	5	109
18	1	68	1	128	8	96
			Girls			
6	5	92	5	167	14	145
7	4	94	5	94	22	134
8	5	112	3	111	17	118
9	5	102	7	139	26	108
10	6	120	6	114	16	136
11	1	110	3	76	31	108
12	7	90	10	108	45	98
13	3	85	3	64	19	90
14	1	58	3	111	9	93
15	0	--	2	132	13	94
16	1	146	2	75	11	90
17	1	86	2	140	7	119
18	1	91	2	182	4	125

[a]Group	Serum alkaline phosphatase concentrations
I	Minus 2 or 3 standard deviations
II	Plus 2 or 3 standard deviations
III	Within ± 1 standard deviations

reached the maximum concentration of serum alkaline phosphatase. The girls displayed the same trend but to a less extent. The lowest carotenoid value of the girls of the three classifications with respect to serum alkaline phosphatase appeared from two to four years after the maximum concentration of serum alkaline phosphatase had been reached by the group.

The hemoglobin concentrations for both sexes and for Groups I and II showed no particularly outstanding differences from 6 to 14 years. From 14 to 18 the boys in Group I had higher concentrations than Group II. The order was reversed for the girls.

<u>Summary</u>

1. The girls and the boys in a sample of Iowa children had serum alkaline phosphatase concentration that attained the maximum concentrations at 11 and 13 years, respectively.

2. The boys and the girls with low serum alkaline phosphatase (Group I) showed no peak value at puberty. The girls and boys with the highest serum alkaline phosphatase concentration (Group II) reached an extremely high peak at 11 and 14 years, respectively. The children with average phosphatase concentrations reached their maximum concentration a year earlier than Group II.

3. Except for the girls with the lowest serum alkaline phosphatase, there was no difference in the relationship between the mean concentration of serum alkaline phosphatase and height was practically the same for the other two groups of girls and for the three groups of boys.

4. The relationship between the serum alkaline phosphatase concentrations and weight appeared to be different before and after 11 or 12 years of age. Before 11 or 12 years the children with the lowest serum alkaline phosphatase concentration tended to weigh less than the children with the highest serum alkaline phosphatase. After 11 years, at each age, the weights of the boys with the highest and lowest concentrations tended to deviate in the same direction from the weights of the boys with average concentrations.

5. No apparent relationship was exhibited between concentration of serum alkaline phosphatase and the various nutrient intakes, as shown by the comparison of the mean nutrient intake for the three groups of boys and of girls.

6. Regardless of classification with reference to serum alkaline phosphatase, the mean serum ascorbic acid concentrations decreased with age to low concentrations at about two to four years after the maximum mean serum alkaline phosphatase had been attained by the group. The boys

with the highest serum alkaline phosphatase concentrations reached the lowest ascorbic acid levels later than the boys with the lowest serum phosphatase concentrations.

7. Regardless of the classification with respect to serum alkaline phosphatase concentration the serum carotenoid concentration decreased with age to a minimum concentration at 15 years for the boys and 13 to 14 years for the girls. In each group the depressions in the mean serum carotenoid concentration followed the maximum mean concentration of serum alkaline phosphatase.

8. No outstanding relationship existed between serum alkaline phosphatase concentration and hemoglobin concentration of the blood for either boys or girls in Groups I and II.

Hemoglobin Concentrations in the Blood of Iowa Children

Hemoglobin concentration in the blood has been widely used as a measure of nutritional status. Its validity in this respect has not been established, partly because it is known to be influenced by many factors and its variability within the limits of normal health is wide. Such factors as age, sex, menstruation, season, geographic location, racial differences, diurnal variation, excitement or fear, gravity and exercise may influence the hemoglobin concentration. Moreover, the results may vary somewhat with the method used for the determination. Nevertheless the hemoglobin concentration may be expected to reflect nutritional status, because the synthesis of this blood constituent by the body involves the use of various amino acids, minerals and vitamins. The globin portion of the molecule contains all the essential amino acids and some of the non-essential amino acids (Block and Bolling, 1945).

The inorganic constituent of hemoglobin is iron. Copper is needed for normal erythropoeisis. It is not essentially a part of the molecule, but is associated with the cytochrome oxidase activity which functions in the hematopoietic activity (Schultze, 1947). Riboflavin may assist in the arrangement of the amino acids in the globin part of the molecule (Cartwright, 1947). Pyridoxine, vitamin B_{12} and folic acid may be associated with metabolism of the amino acids and thus also be associated with the synthesis of hemoglobin.

Investigators differ on the concentrations of hemoglobin to consider as standards for healthy children at different ages and in both sexes. Wintrobe (1946) made a series of suggestions which were higher than the values reported by Macy (1946) on a group of children judged to be in excellent health. Many data on hemoglobin concentration are available. Possibly because of the diversity of methods, lack of information about the nutritional or health status of the children, or the peculiarities of the sample of children, these data have not resulted in standards.

<u>Mean hemoglobin concentration in the blood of a total sample of Iowa children</u>

The hemoglobin concentrations in the blood of Iowa boys and girls were determined by two different methods. During the first year of the study, the only blood constituent determined was the hemoglobin concentration (Ebersole, 1949). The acid hematin technique was used in this determination (Hawk *et al.*, 1947). In the second and third year of the study a battery of tests was added to the measurements of nutritional status. Among these micromethods for blood analysis was an oxyhemoglobin procedure (Bessey and Lowry, 1945) for the determination of the hemoglobin concentrations.

The children studied in the first year attended the independent and consolidated school with grades one to twelve. These children lived in small villages or in open country. In this phase of the study these children will be called "rural" girls and boys. In the second and third year the children attended schools that were located in cities and small towns. These children will be called "urban" boys and girls.

In Figure 38 are presented the mean hemoglobin concentration of each age-sex group of the rural and urban boys and girls. The means for each age-sex group of the rural children were lower than those found for the urban boys and girls. Since a different method was applied in assessing the hemoglobin concentration, the difference between the two groups cannot be ascribed to place of living. Yet, if method of analysis accounted for the difference, the same difference might have been expected throughout the age groups. The difference in hemoglobin concentration of the two groups of boys and girls were considerably greater before 12 years for the girls and 15 years for the boys than after these ages.

In Table 75 are presented the mean daily intakes of the nutrients that are usually considered to be involved in hemoglobin formation of the two groups of Iowa children. It may be noted that the difference in the mean intake of the two groups was not large enough to account for the

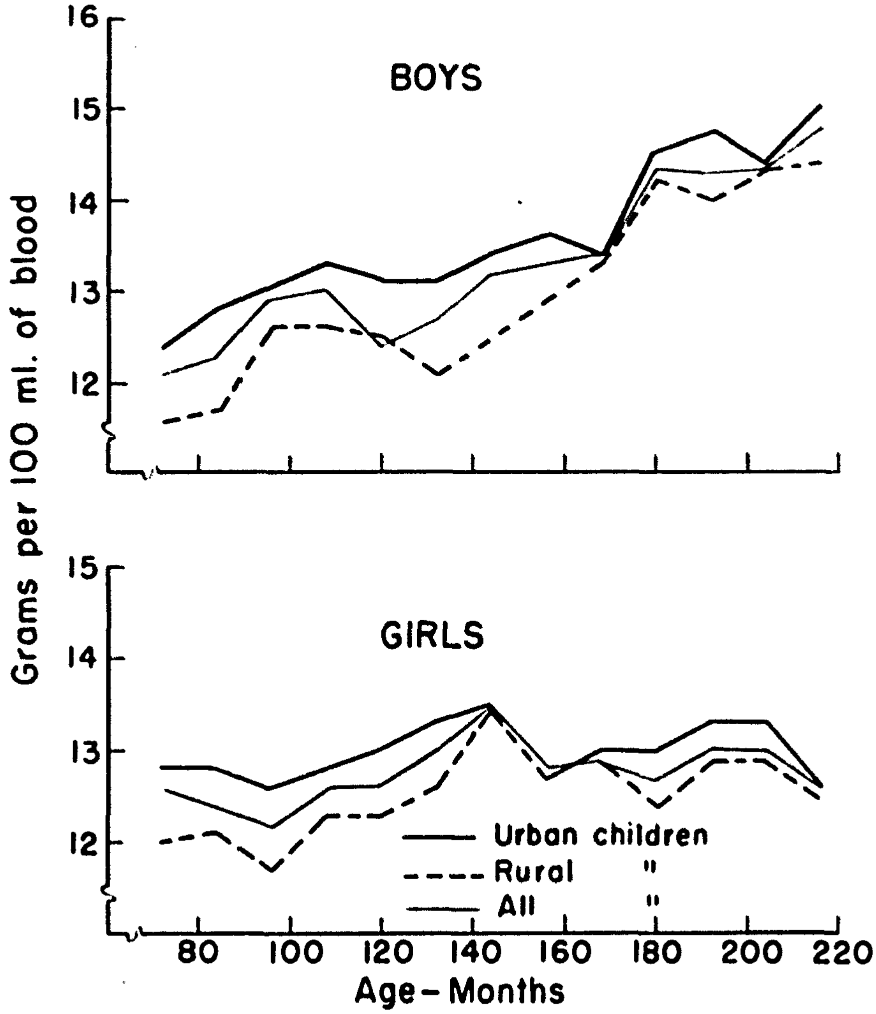

Fig. 38 Mean hemoglobin concentrations in blood of Iowa children

Table 75

Mean Daily Content of Some Nutrients in Diets of Rural and Urban Children of Iowa

	Rural					Urban				
Age yr.	No.	Protein (gm.)	Iron (mg.)	Riboflavin (mg.)	Niacin (mg.)	No.	Protein (gm.)	Iron (mg.)	Riboflavin (mg.)	Niacin (mg.)
					Boys					
6	15	61	9	1.7	11	20	69	10	1.9	11
7	26	66	10	1.9	12	28	66	9	1.8	11
8	14	73	11	2.1	12	37	70	10	2.0	11
9	19	73	12	2.0	13	31	73	11	2.0	13
10	25	71	11	1.9	13	35	76	11	2.0	14
11	22	76	12	2.1	13	26	81	11	2.0	13
12	21	77	12	2.0	13	65	88	13	2.3	15
13	17	83	14	1.9	15	25	90	13	2.4	16
14	23	93	15	2.2	17	16	87	13	2.2	16
15	18	94	16	2.5	18	14	93	14	2.4	15
16	17	102	16	2.5	17	14	96	15	2.5	17
17	14	102	16	2.6	18	6	110	15	3.0	16
18	6	103	16	2.6	18	11	102	15	2.6	18

Table 75 (Cont'd)

Age yr.	Rural No.	Rural Protein (gm.)	Rural Iron (mg.)	Rural Riboflavin (mg.)	Rural Niacin (mg.)	Urban No.	Urban Protein (gm.)	Urban Iron (mg.)	Urban Riboflavin (mg.)	Urban Niacin (mg.)
					Girls					
6	23	62	9	1.6	10	25	60	9	1.7	10
7	16	61	9	1.6	10	31	61	9	1.6	10
8	15	58	9	1.6	9	20	69	9	2.0	11
9	22	67	11	1.6	12	37	72	10	2.0	13
10	31	64	11	1.7	12	28	73	11	2.0	13
11	23	67	10	1.9	12	34	69	10	1.8	11
12	16	80	12	2.0	14	62	80	12	2.0	14
13	19	80	12	2.0	14	25	69	10	1.7	12
14	23	74	12	1.9	13	14	75	12	2.0	13
15	23	72	12	1.7	13	15	80	13	1.9	15
16	21	71	11	1.6	12	15	67	10	1.6	12
17	15	78	12	1.7	14	10	63	10	1.5	11
18	5	72	13	1.4	14	7	76	11	1.7	13.4

difference in the hemoglobin concentrations of the two groups. In fact, there was a slight tendency for the rural children to have higher intakes than the urban children of the various nutrients.

Since there was this difference between the hemoglobin concentration of these two groups of boys and girls, the data for each group will be discussed separately. The mean, standard deviation, standard error of the mean and the range for each age-sex group are presented in Tables 76 and 77.

The mean hemoglobin concentration in the blood of both groups of boys showed a slow, steady increase with age. The same increase may be noted for the girls to 13 years. At 13 years the mean hemoglobin concentration in the blood of the girls decrease sharply and remained approximately at the same level from 14 to 18 years.

The hemoglobin concentrations for the rural boys ranged from 9.0 to 19.3 gram per cent; for the urban boys 11.1 to 17.1 gram per cent; for the rural girls 6.7 to 17.5 gram per cent; for the urban girls 10.2 to 17.9 gram per cent. The hemoglobin concentrations of the rural children covered a wider range of values than those of the urban children.

Table 76

Mean Hemoglobin Concentrations in Blood of Rural Iowa Children

Age yr.	No.	Mean gm.	Standard deviation gm.	Standard error gm.	Range gm.
			Boys		
6	16	11.6	1.02	0.26	10.4 - 13.1
7	28	11.7	1.20	0.23	9.7 - 14.4
8	14	12.6	1.24	0.33	10.8 - 15.9
9	20	12.6	0.85	0.20	11.0 - 15.1
10	25	12.5	1.68	0.34	10.5 - 19.3
11	22	12.1	1.05	0.22	9.0 - 13.9
12	21	12.5[b]	0.71	0.16	11.5 - 13.8
13	17	12.9	1.11	0.28	11.1 - 15.0
14	24	13.3[b]	1.65	0.34	9.0 - 16.5
15	18	14.2[a]	1.19	0.29	12.3 - 16.3
16	19	14.0[a]	1.04	0.24	11.6 - 15.9
17	14	14.3[a]	1.49	0.41	10.7 - 16.1
18	7	14.4[a]	1.00	0.41	13.0 - 15.7
			Girls		
6	23	12.0	0.88	0.18	10.3 - 13.8
7	16	12.1	1.35	0.35	7.8 - 12.9
8	18	11.7	2.23	0.54	7.0 - 15.4
9	24	12.3	1.76	0.37	6.7 - 16.9
10	31	12.3	1.03	0.18	9.8 - 14.6
11	23	12.6	1.06	0.22	10.8 - 14.5
12	16	13.5[b]	1.71	0.43	11.0 - 17.5
13	19	12.8	1.07	0.25	10.9 - 15.6
14	23	12.9[b]	0.97	0.21	9.5 - 14.1
15	23	12.4[a]	1.17	0.24	10.3 - 16.3
16	22	12.9[a]	0.97	0.20	11.1 - 15.0
17	16	12.9[a]	1.25	0.31	11.0 - 16.2
18	5	12.5[a]	1.20	0.54	11.1 - 14.3

[a]Significant at the 1 per cent level.

[b]Significant at the 5 per cent level.

Table 77

Mean Hemoglobin Concentrations in Blood of Urban Iowa Children

Age yr.	No.	Mean gm.	Standard deviation gm.	Standard error gm.	Range gm.
			Boys		
6	20	12.4	0.67	0.15	11.1 - 13.6
7	28	12.8	0.71	0.14	11.3 - 14.7
8	27	13.0	0.91	0.15	11.4 - 16.2
9	32	13.3	0.86	0.16	11.4 - 14.4
10	36	13.1	1.05	0.18	11.3 - 15.1
11	26	13.1	0.77	0.15	11.2 - 14.4
12	65	13.4	0.93	0.12	11.6 - 17.1
13	25	13.6[b]	0.94	0.19	11.8 - 15.9
14	17	13.4[b]	1.04	0.25	12.1 - 15.5
15	14	14.5[b]	0.76	0.20	13.7 - 15.9
16	15	14.7[a]	0.80	0.21	13.0 - 15.6
17	7	14.4[b]	1.12	0.46	13.1 - 16.2
18	11	15.0[a]	1.51	0.48	12.8 - 17.1
			Girls		
6	25	12.8	0.86	0.17	10.3 - 14.0
7	31	12.8	0.72	0.13	11.6 - 14.2
8	21	12.6	0.63	0.16	11.1 - 13.8
9	37	12.8	0.59	0.12	11.0 - 14.9
10	28	13.0	0.70	0.13	11.5 - 14.0
11	34	13.3	0.98	0.17	10.5 - 14.9
12	63	13.5	0.71	0.09	11.7 - 14.7
13	25	12.7[b]	0.71	0.14	11.2 - 14.1
14	14	13.0[b]	0.81	0.22	11.7 - 14.5
15	15	13.0[b]	0.90	0.23	10.5 - 14.0
16	15	13.3[a]	1.79	0.46	10.2 - 17.9
17	10	13.3[b]	0.73	0.28	12.2 - 14.7
18	7	12.6[a]	0.90	0.37	11.2 - 13.4

[a]Significant at the 1 per cent level.

[b]Significant at the 5 per cent level.

The sex differences were particularly noticeable from 14 to 18 years. In the rural group the difference between the two sexes at 12 years was significant at the 5 per cent level, but it was not significant at 13 years. It was again significant at 14 to 18 years. For the urban children significant sex differences appeared first at 13 years and continued to 18 years. Mack et al. (1941) found a consistent sex difference from 12 to 40 years in their observations on 2400 subjects in Pennsylvania. Clayton et al. (1953) observed a lower hemoglobin concentration among the girls of the 13 to 15 year old group than among the boys in the same age group. The Iowa data along with the findings on the children in the Northeast Region (Clayton et al., 1953) are presented in Table 78. The Iowa rural children had lower hemoglobin concentrations than did the children in the Northeast Region. Except for girls 13 to 15 years, the urban Iowa children had concentrations that were equal to those observed by Clayton and co-workers on the children in the Northeast Region. Abbott et al. (1946) did not observe sex differences in the hemoglobin concentrations of the Florida children. These children were under the age of 14 years, also they were poorly nourished.

To study some possible relationships between hemoglobin concentrations and nutrient intake, the regression

Table 78

Mean Hemoglobin Concentrations in the Blood of Children in Iowa and Other Places

Age groups	7-9 years		10-12 years		13-15 years		16-18 years	
Places	No.	Gm.	No.	Gm.	No.	Gm.	No.	Gm.
				Boys				
Iowa								
rural	59	12.2	68	12.4	58	13.5	37	14.2
urban	96	13.0	126	13.3	55	13.8	31	14.8
New York[a]	47	13.1	48	13.3	107	13.9	9	14.3
Maine[a]	--	--	8	13.3	252	13.8	62	14.4
Rhode Island[a]	--	--	--	--	13	14.4	50	14.7
West Virginia[a]	--	--	--	--	--	--	532	15.5
				Girls				
Iowa								
rural	53	12.0	70	12.7	65	12.5	41	12.8
urban	88	12.8	124	13.4	54	12.8	32	13.1
New York[a]	51	13.0	55	13.6	115	13.6	10	13.0
Maine[a]	--	--	11	13.2	316	13.2	64	13.2
Rhode Island[a]	--	--	--	--	44	13.4	155	12.9
West Virginia[a]	--	--	--	--	--	--	387	13.6

[a]Clayton *et al*. (1953).

of hemoglobin on age was calculated separately for each sex and for each of the two groups. The regression was significantly different between the groups of boys and girls, also between the two sexes (see Figure 39). These regressions showed that the hemoglobin concentration in the blood of Iowa children increased significantly with each monthly increase in age.

Since the differences between groups and sexes were significant, the data for each sex and group could not be pooled. Consequently, the relationships between hemoglobin concentrations and intakes of various nutrients were calculated separately. These computations were made on the data for the boys only.

The correlation coefficients between hemoglobin concentrations and the mean daily intakes of certain nutrients are shown below:

	Boys	
	Rural	Urban
Riboflavin	0.21[a]	0.33[a]
Iron	0.26[a]	0.21[a]
Niacin	0.29[a]	0.21[a]
Protein	0.33[a]	0.25[a]
Age	0.74[a]	0.37[a]
No. of boys	237	328

[a]Significant at 1 per cent level.

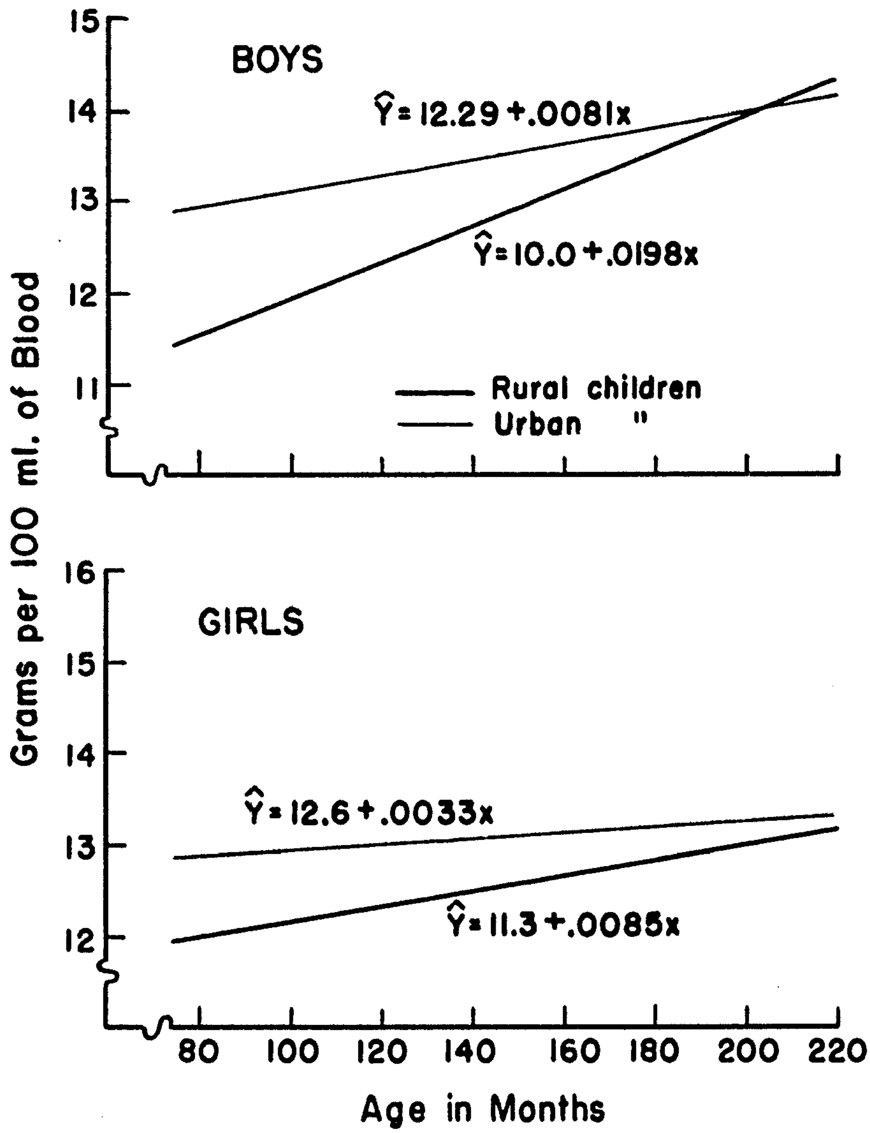

Fig. 39 Regressions of hemoglobin concentrations in blood for two groups of Iowa children

All these correlation coefficients were highly significant. Babcock obtained the following coefficients between hemoglobin and dietary protein and iron:

State	Iron	Protein
Maine	0.141[b]	0.188[b]
Massachusetts	0.245[b]	0.272[b]
New Jersey	-0.171[a]	-0.056
New York	0.213[a]	0.177[a]
Rhode Island	0.269[a]	0.311[a]
West Virginia	0.323[a]	0.289[a]

[a]Significant at 1 per cent level.

[b]Significant at 5 per cent level.

Babcock and co-workers included all the subjects in one state and disregarded age and sex.

When the multiple regression of hemoglobin on the variables riboflavin, niacin, protein, iron and age was computed, it was noted that the addition of the other independent variables, niacin, riboflavin, protein and iron did not appreciably improve the estimate of hemoglobin with age.

The simple linear relationship between hemoglobin and age was $r = 0.74$ for the rural boys and 0.37 for the urban boys. The multiple R was 0.87 for the rural boys and 0.40 for the urban boys.

<u>Study of the three groups of Iowa rural and urban children classified according to hemoglobin concentration in the blood</u>

In order to study the characteristics of the children who had high, low or average hemoglobin concentrations, each age-sex group was divided into three groups. Group I consisted of all the children who were in the second and third standard deviation below the mean; Group II those in the second and third standard deviation above the mean; Group III those within plus or minus one standard deviation.

In Tables 79 and 80 are presented the mean hemoglobin concentrations for each age-sex group. Except for the 7 and 8 year old rural girls with the low hemoglobin concentration (Group I) the means of no group fell below 10 gram per cent.

<u>Physical status</u>. The urban boys with low hemoglobin concentration tended to be shorter and to weigh less than the urban boys with high concentrations. The rural boys and all groups of girls exhibited no definite relationship between physical measurement and hemoglobin concentration.

<u>Nutrient intake</u>. No consistent relation was observed between hemoglobin concentration in the blood of Iowa children and the various nutrient intakes of their diets.

Table 79

Mean Hemoglobin Concentration in Blood of Rural Iowa Children Classified According to Hemoglobin Concentrations

Groups[a]	I		II		III	
Age yr.	No.	Gm.	No.	Gm.	No.	Gm.
			Boys			
6	0	--	2	13.1	14	11.4
7	3	10.1	4	13.8	21	11.6
8	1	10.8	2	15.1	11	12.3
9	2	11.3	2	14.3	16	12.6
10	2	10.7	2	16.8	21	12.3
11	3	10.3	3	13.3	16	12.2
12	2	11.6	4	13.7	15	12.3
13	3	11.4	4	14.4	10	12.8
14	4	10.9	4	15.6	16	13.3
15	4	12.6	4	15.8	10	14.3
16	1	11.6	2	16.1	16	13.9
17	3	12.0	1	16.1	10	14.9
18	1	13.0	0	--	6	14.7
			Girls			
6	10	11.2	1	13.8	12	12.5
7	3	9.2	0	--	13	12.0
8	2	8.3	2	14.7	14	11.8
9	7	10.7	4	14.8	13	12.5
10	3	10.6	4	14.3	24	12.2
11	4	11.0	4	14.2	15	12.5
12	2	10.9	2	16.5	12	13.4
13	3	11.4	1	15.6	15	12.9
14	2	10.7	2	14.1	19	13.0
15	1	10.3	3	14.7	19	12.2
16	4	11.6	4	14.4	14	12.8
17	2	11.3	1	16.2	13	12.9
18	1	11.1	1	14.3	3	12.4

[a]Group - Hemoglobin concentration in blood
I Minus 2 or 3 standard deviations
II Plus 2 or 3 standard deviations
III Within ± 1 standard deviation.

Table 80

Mean Hemoglobin Concentrations in Blood of Urban Iowa Children Classified According to Hemoglobin Concentrations

Groups[a]	I		II		III	
Age yr.	No.	Gm.	No.	Gm.	No.	Gm.
			Boys			
6	3	11.3	3	13.3	14	12.5
7	4	11.7	3	14.2	21	12.8
8	2	11.6	4	15.0	31	12.8
9	5	11.8	6	14.3	21	13.3
10	8	11.7	8	14.6	20	13.1
11	4	11.8	3	14.1	19	13.3
12	10	12.2	7	15.1	48	13.4
13	3	12.1	5	15.0	17	13.4
14	1	12.1	4	15.1	12	13.0
15	2	13.7	3	15.7	9	14.3
16	4	13.6	3	15.6	8	15.0
17	0	--	1	16.2	6	14.1
18	2	13.0	3	16.9	6	14.9
			Girls			
6	3	10.8	11	13.4	11	12.7
7	3	11.7	6	14.0	22	12.7
8	3	11.3	5	13.6	13	12.6
9	11	11.9	6	14.0	20	12.9
10	5	11.9	6	13.9	17	12.9
11	4	11.5	6	14.6	24	13.3
12	7	12.3	12	14.5	44	13.4
13	2	11.5	4	13.8	19	12.6
14	2	11.9	2	14.5	10	12.9
15	2	11.3	2	14.0	11	13.2
16	3	10.6	1	17.9	11	13.6
17	2	12.3	2	14.6	6	13.2
18	1	11.2	0	--	6	12.9

[a]Group - Hemoglobin concentrations in blood
I Minus 2 or 3 standard deviations
II Plus 2 or 3 standard deviations
III Within ± 1 standard deviation.

In Tables 81, 82, 83 and 84 are presented the mean intakes of each group of boys and girls.

Concentration of various blood constituents. Analysis of other blood constituents (serum ascorbic acid, serum carotenoid and serum alkaline phosphatase concentrations) in relation to hemoglobin concentration in the blood was made only on the urban children.

The mean serum ascorbic acid concentrations for each age-sex group classified according to hemoglobin concentration decreased with age so that the minima were reached at 15 to 16 years for boys and 13 to 15 for girls (see Table 85). The urban boys and girls with low hemoglobin concentration tended to have the lowest serum ascorbic acid concentrations. The hemoglobin concentration of the other groups of boys and girls showed less consistent relationship with serum ascorbic acid concentration.

The mean serum carotenoid concentrations for each age-sex group are presented in Table 86. The girls with the low hemoglobin concentration tended to have lower serum carotenoid concentrations than the other two groups.

The mean serum alkaline phosphatase concentration for each age-sex group classified according to hemoglobin concentration are presented in Table 87. The boys from 8 through 13 years with the lowest hemoglobin concentration

Table 81

Mean Daily Food Energy and Nutrient Value of Diets of Rural Iowa Children Classified According to Hemoglobin Concentrations in Blood

Age	No.	Group[a]	Hemo-globin (gm.)	Food energy (cal.)	Protein (gm.)	Animal protein (gm.)	Other sources protein (gm.)	Iron (mg.)	Ribo-flavin (mg.)	Niacin (mg.)
					Boys					
6	0	I	--	--	--	--	--	--	--	--
	2	II	13.1	2030	63	38	25	11	1.8	11
	13	III	11.5	2111	61	35	26	9	1.6	11
7	3	I	10.1	2396	68	34	34	12	1.8	13
	4	II	13.8	2025	59	34	25	9	1.4	11
	19	III	11.6	2307	67	38	29	10	2.0	12
8	1	I	10.8	2766	78	42	36	13	2.0	13
	2	II	15.1	2667	83	55	28	11	2.6	13
	11	III	12.3	2349	70	41	29	11	2.1	12
9	2	I	11.3	2454	74	41	33	11	1.9	11
	2	II	14.3	2576	73	38	35	12	1.7	13
	15	III	12.5	2522	72	39	33	12	2.0	13

[a]Group - Hemoglobin concentration in blood
I — Minus 2 or 3 standard deviations
II — Plus 2 or 3 standard deviations
III — Within ± 1 standard deviation.

Table 81 (Cont'd)

Age	No.	Group[a]	Hemo-globin (gm.)	Food energy (cal.)	Protein (gm.)	Animal protein (gm.)	Other sources protein (gm.)	Iron (mg.)	Ribo-flavin (mg.)	Niacin (mg.)
10	2	I	10.7	2717	78	45	33	12	2.3	16
	2	II	16.8	2335	70	38	33	11	1.8	14
	21	III	12.3	2370	71	40	31	11	1.9	12
11	3	I	10.3	2587	80	50	30	12	2.4	13
	3	II	13.3	2581	74	34	40	13	2.0	14
	16	III	12.2	2695	76	40	36	11	2.0	13
12	2	I	11.6	4091	119	67	52	18	3.1	21
	4	II	13.7	2821	76	33	43	12	2.0	14
	15	III	12.3	2406	72	36	36	12	1.9	12
13	3	I	11.4	2621	79	40	39	14	1.9	15
	4	II	14.4	3043	93	52	40	13	2.3	14
	10	III	12.8	2962	80	41	39	14	1.8	15
14	4	I	10.9	2969	86	45	41	15	1.7	17
	4	II	15.6	3614	111	69	42	17	2.4	20
	15	III	13.4	2950	90	50	40	14	2.3	16
15	4	I	12.6	3644	98	53	44	19	3.2	18
	4	II	15.8	3190	94	56	38	14	3.1	17
	10	III	14.3	3300	93	47	46	17	2.0	18
16	1	I	11.6	4366	140	101	39	19	2.8	20
	2	II	16.1	3586	96	40	55	16	1.7	17
	14	III	14.1	3458	101	59	42	16	2.6	17

Table 81 (Cont'd)

Age	No.	Group[a]	Hemo-globin (gm.)	Food energy (cal.)	Protein (gm.)	Animal protein (gm.)	Other sources protein (gm.)	Iron (mg.)	Ribo-flavin (mg.)	Niacin (mg.)
17	3	I	12.0	3635	102	48	54	19	2.3	18
	1	II	16.1	1843	76	49	28	8	2.0	10
	10	III	14.9	3431	105	62	43	16	2.7	19
18	1	I	13.0	3839	90	41	49	18	2.1	17
	0	II	--	--	--	--	--	--	--	--
	5	III	15.3	3637	105	63	42	15	2.6	18

Table 82

Mean Daily Food Energy and Nutrient Value of Diets of Urban Iowa Children Classified According to Hemoglobin Concentrations in Blood

Age	No.	Group[a]	Hemo-globin (gm.)	Food energy (cal.)	Protein (gm.)	Animal protein (gm.)	Other sources protein (gm.)	Iron (mg.)	Ribo-flavin (mg.)	Niacin (mg.)
					Boys					
6	3	I	11.3	2176	71	44	28	10	2.0	11
	3	II	13.3	2440	71	45	28	9	1.9	10
	14	III	12.5	2162	68	42	26	10	1.9	11
7	4	I	11.7	1903	59	36	23	8	1.6	9
	3	II	14.2	2338	78	51	25	11	2.2	13
	21	III	12.8	2074	65	37	28	9	1.8	10
8	2	I	11.6	2129	62	36	26	9	1.6	10
	4	II	15.0	2301	74	48	26	10	2.2	12
	31	III	12.8	2171	70	44	26	10	2.0	11
9	5	I	11.8	2300	67	37	29	10	1.8	12
	6	II	14.3	2384	72	44	28	10	2.1	13
	20	III	13.3	2363	75	43	32	11	2.0	12

[a]Group - Hemoglobin concentrations in blood
I Minus 2 or 3 standard deviations
II Plus 2 or 3 standard deviations
III Within ± 1 standard deviation.

Table 82 (Cont'd)

Age	No.	Group[a]	Hemo-globin (gm.)	Food energy (cal.)	Protein (gm.)	Animal protein (gm.)	Other sources protein (gm.)	Iron (mg.)	Ribo-flavin (mg.)	Niacin (mg.)
10	8	I	11.7	2574	79	45	34	12	2.1	14
	8	II	14.6	2380	76	46	30	11	2.0	14
	19	III	13.1	2393	75	43	32	11	2.0	13
11	4	I	11.8	2194	70	44	26	9	2.0	11
	3	II	14.1	3087	97	57	40	13	2.3	20
	19	III	13.3	2616	81	49	32	12	2.0	13
12	10	I	12.2	2983	92	51	40	14	2.3	17
	7	II	15.1	3105	98	58	40	14	2.7	16
	48	III	13.4	2549	85	49	36	13	2.2	14
13	3	I	12.1	3087	92	52	40	14	2.2	15
	5	II	15.0	2903	91	54	37	14	2.7	16
	17	III	13.4	2874	90	53	37	13	2.3	16
14	1	I	12.1	2395	75	48	27	11	1.5	14
	4	II	15.1	2669	82	50	32	13	1.9	14
	11	III	13.0	3120	90	49	41	13	2.4	16
15	2	I	13.7	3629	104	55	49	17	2.8	17
	3	II	15.7	3221	89	54	35	13	2.6	14
	9	III	14.3	3115	92	58	34	14	2.2	15
16	4	I	13.6	3193	94	55	39	15	2.3	17
	3	II	15.6	2997	87	50	37	14	2.4	14
	7	III	15.0	3381	101	60	41	15	2.6	17

Table 82 (Cont'd)

Age	No.	Group[a]	Hemo-globin (gm.)	Food energy (cal.)	Protein (gm.)	Animal protein (gm.)	Other sources protein (gm.)	Iron (mg.)	Ribo-flavin (mg.)	Niacin (mg.)
17	0	I	--	--	--	--	--	--	--	--
	1	II	16.2	2159	77	53	24	11	1.8	12
	5	III	14.1	3843	117	75	42	11	3.2	12
18	2	I	13.0	2903	80	41	40	13	1.5	15
	3	II	16.9	3840	128	79	49	19	2.6	22
	6	III	14.9	3184	97	57	40	14	2.9	18

Table 83

Mean Daily Food Energy and Nutrient Value of Diets of Rural Iowa Children Classified According to Hemoglobin Concentrations in Blood

Age	No.	Group[a]	Hemo-globin (gm.)	Food energy (cal.)	Protein (gm.)	Animal protein (gm.)	Other sources protein (gm.)	Iron (mg.)	Ribo-flavin (mg.)	Niacin (mg.)
				Girls						
6	3	I	10.7	2259	66	38	28	10	1.9	11
	1	II	13.8	1136	38	25	13	5	1.1	7
	19	III	12.1	2031	62	37	25	9	1.6	10
7	3	I	9.2	2179	65	38	27	11	1.9	13
	0	II	--	--	--	--	--	--	--	--
	13	III	12.0	1994	57	35	22	9	1.6	10
8	2	I	8.3	2130	61	36	25	9	1.8	10
	2	II	14.7	1684	50	31	19	8	1.4	8
	11	III	12.3	1980	58	33	25	9	1.6	9
9	1	I	6.7	2862	78	42	36	13	1.8	13
	4	II	14.8	1863	59	33	26	9	1.4	10
	17	III	12.2	2145	68	35	33	11	1.6	13

[a]Group - Hemoglobin concentrations in blood
I Minus 2 or 3 standard deviations
II Plus 2 or 3 standard deviations
III Within ± 1 standard deviation.

Table 83 (Cont'd)

Age	No.	Group[a]	Hemo-globin (gm.)	Food energy (cal.)	Protein (gm.)	Animal protein (gm.)	Other sources protein (gm.)	Iron (mg.)	Ribo-flavin (mg.)	Niacin (mg.)
10	3	I	10.6	2242	66	36	29	11	1.9	11
	4	II	14.3	2185	61	29	32	12	1.4	11
	24	III	12.2	2309	64	32	32	11	1.7	12
11	4	I	11.0	2037	62	33	29	11	1.8	12
	4	II	14.2	1897	52	25	27	8	1.3	10
	15	III	12.5	2423	73	38	35	11	2.2	13
12	2	I	10.9	2686	76	40	37	12	1.8	16
	2	II	16.5	2878	90	52	38	14	2.1	16
	12	III	13.4	2479	79	41	38	11	2.0	13
13	3	I	11.4	2763	82	44	39	11	2.2	12
	1	II	15.6	3028	101	67	35	12	3.0	13
	15	III	13.0	2612	79	41	38	13	1.9	14
14	2	I	10.7	2507	77	44	33	12	1.9	12
	2	II	14.1	3072	83	38	45	15	1.9	15
	19	III	13.0	2530	73	40	33	12	1.9	13
15	1	I	10.3	2763	75	49	26	14	2.2	12
	3	II	14.7	2304	75	45	30	11	1.9	13
	19	III	12.2	2525	71	37	34	12	1.7	13
16	4	I	11.6	2839	73	34	39	14	1.8	13
	4	II	14.4	2227	75	48	27	11	1.8	13
	13	III	12.8	2394	68	36	32	11	1.7	12

Table 83 (Cont'd)

Age	No.	Group[a]	Hemo-globin (gm.)	Food energy (cal.)	Protein (gm.)	Animal protein (gm.)	Other sources protein (gm.)	Iron (mg.)	Ribo-flavin (mg.)	Niacin
17	2	I	11.3	2406	74	41	33	12	1.9	12
	1	II	16.2	2137	68	49	20	10	2.1	13
	12	III	13.0	2640	80	45	35	12	1.7	14
18	1	I	11.1	2607	73	32	41	13	1.4	14
	1	II	14.3	2738	80	40	27	15	1.5	17
	3	III	12.4	2790	68	30	38	12	1.3	13

Table 84

Mean Daily Food Energy and Nutrient Value of Diets of Urban Iowa Children Classified According to Hemoglobin Concentrations in Blood

Age	No.	Group[a]	Hemoglobin (gm.)	Food energy (cal.)	Protein (gm.)	Animal protein (gm.)	Other sources protein (gm.)	Iron (mg.)	Riboflavin (mg.)	Niacin (mg.)
					Girls					
6	3	I	10.8	1743	52	27	25	8	1.3	10
	3	II	13.6	2010	67	44	23	9	1.9	11
	19	III	12.7	1945	61	37	24	9	1.7	10
7	3	I	11.7	2003	63	40	23	9	1.7	10
	6	II	14.0	1864	59	38	21	9	1.7	11
	22	III	12.7	1990	61	36	25	9	1.7	11
8	3	I	11.3	2025	68	42	26	8	2.0	11
	5	II	13.6	2066	69	43	27	10	1.9	11
	12	III	12.6	2107	68	44	24	10	2.1	11
9	9	I	11.9	2249	66	36	30	10	1.7	12
	6	II	14.0	2323	71	41	30	10	1.2	13
	22	III	12.9	2362	74	45	29	10	2.1	13

[a]Group - Hemoglobin concentration in blood
I Minus 2 or 3 standard deviations
II Plus 2 or 3 standard deviations
III Within ± 1 standard deviation.

Table 84 (Cont'd)

Age	No.	Group[a]	Hemo-globin (gm.)	Food energy (cal.)	Protein (gm.)	Animal protein (gm.)	Other sources protein (gm.)	Iron (mg.)	Ribo-flavin (mg.)	Niacin (mg.)
10	5	I	11.9	2249	69	39	30	11	1.6	12
	6	II	13.9	2214	77	49	28	11	2.3	14
	17	III	12.9	2329	72	42	30	11	2.0	12
11	4	I	11.5	2438	76	43	33	11	1.9	14
	6	II	14.6	1943	63	39	25	10	1.6	11
	24	III	13.3	2268	70	40	30	11	1.8	11
12	7	I	12.3	2178	71	42	29	9	1.8	12
	12	II	14.5	2670	81	47	34	13	2.0	14
	43	III	13.4	2639	82	46	36	12	2.0	14
13	2	I	11.5	2441	74	41	34	12	1.9	12
	4	II	14.0	2758	82	43	38	12	1.9	16
	19	III	12.6	2228	66	34	32	10	1.6	12
14	2	I	11.9	2620	76	47	28	13	2.8	12
	2	II	14.5	2586	88	55	33	13	2.2	13
	10	III	12.9	2238	72	42	30	11	1.9	13
15	2	I	11.3	2755	74	49	24	13	1.9	16
	2	II	14.0	2551	77	42	35	12	1.7	15
	11	III	13.2	2799	82	45	37	13	1.9	15
16	3	I	10.6	2488	78	54	25	11	2.0	15
	1	II	17.9	1727	45	26	19	8	1.8	9
	11	III	13.6	2058	66	41	25	10	1.5	11

Table 84 (Cont'd)

Age	No.	Group[a]	Hemo- globin (gm.)	Food energy (cal.)	Protein (gm.)	Animal protein (gm.)	Other sources protein (gm.)	Iron (mg.)	Ribo- flavin (mg.)	Niacin (mg.)
17	2	I	12.3	2456	74	39	35	12	2.0	12
	2	II	14.6	2374	74	45	29	11	2.0	11
	6	III	13.2	1896	56	31	25	9	1.3	10
18	1	I	11.2	2870	95	68	27	13	2.2	17
	0	II	--	--	--	--	--	--	--	--
	6	III	12.9	2309	73	43	30	11	1.6	13

Table 85

Mean Serum Ascorbic Acid Concentrations of Urban Iowa Children Classified According to Hemoglobin Concentration in Blood

Groups[a]	I		II		III	
	No.	Mg.	No.	Mg.	No.	Mg.
			Boys			
6	3	0.68	3	0.81	14	0.98
7	4	0.65	3	0.89	19	0.86
8	2	0.50	4	0.74	31	0.90
9	5	0.61	6	0.96	21	1.20
10	8	0.73	6	0.80	18	0.83
11	2	0.94	2	0.91	20	0.88
12	10	0.74	7	0.52	47	0.74
13	3	0.68	5	0.62	17	0.72
14	1	0.67	4	1.31	12	0.63
15	2	0.44	3	0.43	9	0.53
16	4	0.79	3	0.37	8	0.53
17	0	--	1	0.51	6	0.61
18	2	0.34	2	0.81	6	0.40
			Girls			
6	3	1.03	3	0.51	18	1.02
7	3	1.10	6	1.07	22	1.03
8	3	0.68	5	1.37	13	0.87
9	9	0.70	6	1.05	22	1.01
10	5	0.45	6	1.11	17	1.12
11	4	0.80	6	0.54	24	0.73
12	6	0.72	12	0.78	44	0.72
13	2	0.27	4	0.35	19	0.54
14	2	0.40	2	1.47	9	0.43
15	2	0.14	2	0.45	11	0.52
16	3	0.61	1	0.38	11	0.71
17	2	0.87	2	1.27	6	0.97
18	1	1.66	0	--	6	0.90

[a]Groups - Hemoglobin concentrations in blood
I Minus 2 or 3 standard deviations
II Plus 2 or 3 standard deviations
III Within ± 1 standard deviation.

Table 86

Mean Serum Carotenoid Concentration of Urban Iowa Children Classified According to Hemoglobin Concentrations in Blood

Groups[a]	I		II		III	
	No.	Mcg.	No.	Mcg.	No.	Mcg.
			Boys			
6	3	104	3	100	14	108
7	3	107	3	124	19	128
8	2	116	4	119	28	116
9	5	95	6	85	20	121
10	8	127	8	128	18	121
11	4	140	3	86	19	116
12	10	100	6	94	49	108
13	3	90	5	97	17	108
14	1	88	4	82	12	91
15	2	47	2	52	9	83
16	4	109	2	82	7	67
17	0	--	1	154	6	98
18	2	145	2	82	6	85
			Girls			
6	3	86	2	168	19	144
7	3	105	6	135	22	121
8	3	80	5	126	13	120
9	8	101	6	115	23	116
10	5	105	6	130	17	134
11	4	132	6	84	24	106
12	6	90	10	94	46	101
13	2	86	4	93	19	85
14	2	112	2	111	9	87
15	2	74	2	113	11	101
16	3	72	1	89	10	98
17	2	111	2	127	6	120
18	1	165	0	--	6	132

[a]Groups - Hemoglobin concentrations in blood
I — Minus 2 or 3 standard deviations
II — Plus 2 or 3 standard deviations
III — Within ± 1 standard deviation.

Table 87

Mean Serum Alkaline Phosphatase Concentration of Urban Iowa Children Classified According to Hemoglobin Concentration in Blood

Groups[a]	I		II		III	
	No.	NP.U.[b]	No.	NP.U.[b]	No.	NP.U.[b]
			Boys			
6	3	4.83	3	4.20	14	4.43
7	3	5.80	3	6.15	22	4.94
8	2	4.56	4	4.94	31	5.48
9	5	5.24	6	5.26	21	5.97
10	8	3.76	8	5.93	19	4.82
11	3	3.88	3	4.64	20	4.89
12	10	5.61	7	5.92	48	6.16
13	3	3.33	4	7.94	18	6.58
14	1	6.80	4	5.27	12	6.19
15	2	8.66	3	3.32	9	5.55
16	4	4.81	3	3.70	8	4.11
17	0	--	1	3.56	6	3.81
18	2	3.42	2	2.57	6	2.07
			Girls			
6	3	5.09	3	4.68	19	5.04
7	3	3.78	6	5.38	21	5.41
8	3	5.59	5	4.54	13	6.30
9	9	4.71	6	5.97	22	5.34
10	5	5.92	6	5.91	17	5.59
11	4	5.70	6	4.94	23	6.55
12	7	5.62	12	5.91	44	5.23
13	2	7.20	4	3.11	19	4.25
14	2	2.73	2	4.55	10	2.90
15	2	1.99	2	2.23	11	2.84
16	3	1.99	1	1.44	11	2.10
17	2	1.40	2	1.94	6	1.51
18	1	2.22	0	--	8	1.14

[a]Groups - Hemoglobin concentration in blood
I — Minus 2 or 3 standard deviations
II — Plus 2 or 3 standard deviations
III — Within ± 1 standard deviation

[b]Nitrophenol units.

tended to the lowest serum alkaline phosphatase concentration, but from 14 to 18 they had the highest phosphatase concentrations. The girls exhibited no relationship between hemoglobin concentrations and serum alkaline phosphatase concentrations.

Summary

1. Both the rural and urban boys demonstrated a slow steady increase in hemoglobin concentration with age. Hemoglobin concentrations for the rural and urban girls from 6 to 13 years increased with age, but decreased noticeably between 13 and 14 years. This lower concentration was maintained to 18 years.

2. There were no definite sex differences from 6 to 12 years in either group. Significant sex differences appeared at 12 years for the rural children, not at 13 years, and again at 14 years. The urban children showed sex differences from 13 to 18 years.

3. The regression of hemoglobin on age was significantly different for boys and for girls, also for the rural children and for the urban children.

4. For boys the mean daily intakes of protein, niacin, riboflavin and iron were significantly correlated with hemoglobin but age was more highly correlated with hemoglobin than were the dietary constituents.

5. There was no outstanding relationship between hemoglobin concentration and height, weight and dietary intakes of the various nutrients.

6. The girls and boys with low hemoglobin concentrations tended to have lower serum ascorbic and serum carotenoid concentrations than the children with high or average hemoglobin concentrations.

7. The boys with low hemoglobin concentrations from 6 to 13 years had lower serum alkaline phosphatase concentrations than did the boys with high hemoglobin concentrations. After 13 years they had the highest serum alkaline phosphatase concentrations. The other groups of boys and girls exhibited no relationship between the two blood constituents.

INTERRELATIONSHIPS AMONG MEASUREMENTS OF NUTRITIONAL STATUS AND NUTRIENT INTAKE

In this study a systematic analysis has been made of certain body measurements and certain blood constituents in relation to each other and to the mean daily intake of nutrients. An attempt has been made to observe relationships that exist among height, weight and developmental level and concentrations of four blood constituents; namely, serum ascorbic acid, serum carotenoid, serum alkaline phosphatase concentrations, and hemoglobin concentrations in blood, and nutrient intake.

The height-weight data in this study may be used as a standard of reference for the heights and weights of other Iowa children. The Iowa children in this study were selected randomly from a large population of school children. It can be assumed that the children in this study were in a normal state of health for Iowa school children, since they were attending school regularly. Moreover, these data are in close agreement with those obtained in previous studies on the measurements of Iowa children. Because of the nature of the sampling, the body measurements in this study should serve as a more reliable basis of comparison than the data in the earlier studies, which represented the measurements of special groups.

The following discussion deals primarily with body measurements in relation to biochemical and dietary observations, and secondly, with biochemical measurements in relation to body measurements and dietary observations.

Interrelationships among Body Measurements and Nutrient Intakes or Blood Constituents of Iowa Children

Each age-sex group was divided into three smaller groups according to mean and standard deviation of the age-sex group. Among the different categories of body measurements there were groups of children who were classified as tallest, heaviest or in highest developmental levels; and other groups who were classified as shortest, lightest or in lowest developmental levels; and others who were designated as average in height, in weight or in developmental level. The dietary and biochemical observations for each grouping were investigated by comparing the means of the groups.

The boys who were tallest, heaviest and with highest developmental level (Group II) tended to have higher intakes of calories, protein, calcium, iron, vitamin C, thiamine, riboflavin and niacin than the boys who were shortest, lightest and with lowest developmental level (Group I).

For the girls the relationships between the various body measurements and nutrients in the diet were less distinct than those noted for the boys (see Table 88). Throughout the school years the relationship with nutrient intake was more evident in height than in weight or developmental level. In other words, the tallest girls tended to have greater intakes of most nutrients than did the shortest girls. For girls below the teen ages weight was related to nutrient intake. In these age groups the heaviest girls, and girls with the highest developmental level had intakes that were higher than the girls of lightest or lowest developmental level. After 13 years the girls who were heaviest and of highest developmental level actually had lower mean intakes of most of the nutrients than the girls who were lightest and of lowest developmental level.

The higher nutrient intake of the boys and younger girls may in part be responsible for the greater height, weight and developmental level. Yet, other conditions must be considered before such relationships can be

Table 88

Ages When Food Energy Value and Nutrient Intake of Diets of Iowa Children in Group II of Various Body Measurements Exceeded Group I

Nutrient	Body measurement	Boys	Girls
		Year of age	Year of age
Food energy value	Height	6,8,9,11,12,13,14,15,16,17	6,8,10,11,12,13,14,15,17
	Weight	6,7,8,9,11,12,13,14,15,16,17,18	6,7,8,10,11,13
	D.L.[a]	6,7,8,9,11,12,13,14	6,7,9,10,11,13,18
Protein	Height	7,8,9,11,12,13,14,15,16,17	6,7,8,9,10,11,12,13,14,15,16,17,18
	Weight	6,7,8,9,11,12,13,14,15,16,17,18	6,7,8,10,11,13
	D.L.	6,7,9,11,12,13,14,15,16,17,18	6,7,8,10,11,13
Calcium	Height	8,9,11,12,13,14,15,17,18	6,7,8,9,10,11,12,16,17,18
	Weight	6,7,11,12,13,14,15,16,17	6,7,8,10,11,13
	D.L.	6,7,8,9,10,11,12,13,14,16,18	6,7,8,10,11,13
Iron	Height	6,8,9,10,11,12,13,14,15,17	6,8,9,10,11,13,14,17
	Weight		
	D.L.	6,7,8,9,11,12,13,14,15,17,18	6,7,8,9,10,11,18
Vitamin C	Height	7,8,9,10,11,12,13,14,18	6,7,8,10,11,12,13,16,17,18
	Weight	6,7,8,9,10,11,12,13,16,17,18	6,7,8,9,10,12,13,14,17,18
	D.L.	6,7,8,9,10,11,12,15,16,18	6,7,8,10,12,13,15,17
Thiamine	Height	6,7,8,9,10,11,12,13,14,15,17,18	6,7,8,9,10,11,12,13,14,17,18
	Weight	6,7,8,9,11,12,13,14,15,17,18	6,7,8,10,11,13,14
	D.L.	6,7,8,11,12,13,14,15,16,17,18	6,7,8,9,10,11

[a]Developmental level according to Wetzel Grid.

Table 88 (Cont'd)

Nutrient	Body measurement	Boys	Girls
		Year of age	Year of age
Ribo-flavin	Height	6,7,8,9,11,12,13,14,15,16,17,18	6,7,8,9,10,11,12,13,14,15,16,17,18
	Weight	6,7,8,10,11,12,13,14,15,16,17	6,7,8,10,11,13,14
	D.L.	6,7,11,12,13,14,15	6,7,8,9,10,13,14
Niacin	Height	6,7,8,9,11,12,13,17	6,8,10,11,12,13,14,16,17,18
	Weight	6,7,8,9,11,12,13,14,16,17	6,7,8,10,11,13,14
	D.L.	6,7,8,9,11,12,13,14,16,17	6,7,8,10,11,13,17,18

established. The children who were tallest, heaviest and of highest developmental level may have had genetic patterns that induced the greater height, weight and developmental level. Also they may have had more favorable environmental conditions. A question may be raised, as to whether the category of greatest physical development is the most desirable.

The relationship between developmental level and food intakes was similar to the relationship with weight, although height and weight were considered in determining developmental level.

In Table 89 are presented the ages when the nutrient intake of the various groups of boys and girls followed the same order as the classification of the different body measurements. That is, the boys and girls who were tallest, heaviest and of highest developmental level (Group II) had the highest values for nutrient intake; those who were shortest, lightest and of lowest developmental level (Group I) had the lowest values for nutrient intake; and those with average body measurements had values for the nutrient intake intermediate to those of the other two groups (Group III).

Boys tended to have nutrient intakes that followed the classification of the three body measurements more often before 13 years than afterwards.

Table 89

Ages When Food Energy Value and Nutrient Intake of Diets of Iowa Children Followed the Same Direction as Groups II, III and I of Various Body Measurements

Nutrient	Body measurement	Boys	Girls
		Year of age	Year of age
Food energy value	Height	8,9,12,13,14,17	8,10,11,14,17
	Weight	6,7,8,12,13,14	8,10,13
	D.L.[a]	6,7,9,12,13,14	8,10,13
Protein	Height	8,9,11,12,13,14,16,17	6,8,10,11,16,17
	Weight	6,7,8,9,11,12,13,14	6,7,8,10,13
	D.L.	6,7,9,11,12,13,14	6,7,8,10
Calcium	Height	9,12,13,14,16,17	6,7,8,9,10,11,12,16,18
	Weight	7,12,13,16	6,7,8,9,10,11,13
	D.L.	6,9,12,13,15,16	6,7,8,10,11
Iron	Height	6,8,9,12,13,14,17	8,9,10,14,16
	Weight		
	D.L.	6,7,8,12,13	10
Vitamin C	Height	8,10,12,16	6,8,9,10,12,16,18
	Weight	7,8,11,12,18	8,9,11,12,13,14
	D.L.	7,10,11,12,18	9,10,12,13,14

[a]Developmental level according to Wetzel Grid.

Table 89 (Cont'd)

Nutrient	Body measurement	Boys: Year of age	Girls: Year of age
Thiamine	Height	9,10,11,12,13	8,9,10,11,17
	Weight	6,7,8,11,12,13,14	6,7,8,13
	D.L.	6,7,8,11,12,13,14,15	6,7,8,11
Ribo-flavin	Height	8,9,10,11,12,13,14,15,16,17	6,7,9,10,11,14,16,18
	Weight	7,12,13,14,15,16	6,8,10,13
	D.L.	6,7,10,11,12,13,14,15	6,7,8,10
Niacin	Height	8,9,11,13,17	8,10,11,13,14,18
	Weight	6,8,11,12	8,10,11,13
	D.L.	6,7,8,11,12	8,10,13

When the girls were classified according to height their mean daily nutrient intakes tended to rate high, intermediate or low in the order of their height classification. For the girls under 10 years the values of their dietary intakes of the various nutrients followed the classification of weight or developmental level more often than occurred above 10 years.

The children who were heaviest and tallest tended to have higher protein and riboflavin intakes than those who were lightest and shortest.

The data in this analysis strongly indicated that body measurements of boys and younger girls were related to nutrient intake. This study has revealed relationships between physical measurements and nutrient intake among children of a normal population. The validity of the relationships per se is subject to questions which arise from small numbers in the extreme groups. A study designed to investigate these suggested relationships would require wider sampling of children in the extreme groupings.

With the average group the relationship between developmental level and nutrient intake was greater than that in the other two groups as was shown by the regression of developmental level on various nutrient intakes. The relationship between developmental level and protein was not so evident when the age factor was partially removed by computing the regressions at each age for the two sexes, regardless of high, low or intermediate classification.

The boys and younger girls with average or greater than average physical development had diets in which the mean daily intakes tended to conform to the allowances except in calcium. The boys and girls, except at the teen ages, who were shortest, lightest and developing slowly had nutrient intakes less than the allowances at more ages than had the boys and girls in the other two groups. The teen-age girls who were tallest, heaviest and developing rapidly and those who were average in height, weight and developmental level had dietary intakes that were generally below the allowances (see Table 90).

It appears from these data that physical developmental may vary with the dietary practices of children. Therefore, the needs of the children at various physiological ages should be studied. The lack of relationships between developmental level and nutrient intake of teen-age girls suggests the need of further study of the actual needs of these girls.

Table 90

Ages When Food Energy Value and Nutrient Content of the Diets of Iow Classified According to Various Body Measurements Were Less Than the

Nutrient	Body measure-ments	Group I Boys	Group I Girls	Group II Boys	Group II Girls
Food energy value	Height	9,12-18	8,10,11,13-17	18	13,15,1
	Weight	8,12-18	8,10,11,13,14	16-18	11,12,1
	D.L.[a]	8,12-18	8,10,11,13,14,17	15,16,17	11,12,1
Protein	Height	13,17	8,10,11,13-17	- - -	13-16
	Weight	8,13,16-18	6-8,10,11,13,14,16,17	17	14-18
	D.L.[a]	8,11,13,14,16,17	7,8,10,11,13,14,16	17,18	14-18
Calcium	Height	8-18	6-18	10,14,15,18	9-18
	Weight	6,7,10,12-18	6-17	9,10,13-17	9-12,14
	D.L.[a]	6,7,9-18	6-17	13-17	9-18
Iron	Height	13,17	6,8-18	18	12-18
	Weight	- - -	- - -	- - -	- - -
	D.L.[a]	8,11-17	6,7,8,10,11,13-18	16,17,18	11-18
Vitamin C	Height	12-14,18	12,13,15,17	13,14,17,18	13-15
	Weight	11-14,16-18	12-14,17,18	13,14,17	11,16
	D.L.[a]	12-14,16-18	12,13,14,17,18	13,14,17	16,18
Thiamine	Height	9-11,13,17,18	8-11,13-18	10	13-17
	Weight	8,9,11-14,16-18	6-8,10,11,13-15	10,16-18	9-18
	D.L.[a]	7,8,13-17	6,8-11,13,14	16,17,18	12-18
Riboflavin	Height	13,17	7,11,13-18	- - -	14-18
	Weight	12-14,16,17	11,13-15	18	13-18
	D.L.[a]	12-14,16,18	13	- - -	13,15-1
Niacin	Height	13,17	8,11,13-18	16	13-18
	Weight	8,11,13,16-18	8,11,13,14	16,17	14-18
	D.L.[a]	8,13,16,17	8,11,13,14,17	16,17	- - -

[a]Developmental level as obtained from the Wetzel Grid

Table 90

lue and Nutrient Content of the Diets of Iowa Children
Various Body Measurements Were Less Than the Allowances

	Group II		Group III	
Girls	Boys	Girls	Boys	Girls
8,10,11,13-17	18	13,15,16	12-18	10-14,16-18
8,10,11,13,14	16-18	11,12,14,16-18	13-18	10,11,13,14,16
8,10,11,13,14,17	15,16,17	11,12,14,16,17	13,14,15,18	10,11,13,14,16,18
8,10,11,13-17	- - -	13-16	- - -	14-18
6-8,10,11,13,14,16,17	17	14-18	- - -	13-18
7,8,10,11,13,14,16	17,18	14-18	- - -	13-18
6-18	10,14,15,18	9-18	9-16,18	9-18
6-17	9,10,13-17	9-12,14-18	10-16,18	6,7,9-18
6-17	13-17	9-18	10-16-18	6,7-9-18
6,8-18	18	12-18	- - -	10-18
- - -	- - -	- - -	- - -	- - -
6,7,8,10,11,13-18	16,17,18	11-18	11,14	11,14-18
12,13,15,17	13,14,17,18	13-15	15,18	- - -
12-14,17,18	13,14,17	11,16	18	13
12,13,14,17,18	13,14,17	16,18	18	13
8-11,13-18	10	13-17	10-14	10-18
6-8,10,11,13-15	10,16-18	9-18	10,11,16,18	10,11,13-18
6,8-11,13,14	16,17,18	12-18	- - -	11,13
7,11,13-18	- - -	14-18	- - -	13,15,16,18
11,13-15	18	13-18	17	14-18
13	- - -	13,15-18	17	15-18
8,11,13-18	16	13-18	15	13-18
8,11,13,14	16,17	14-18	15	- - -
8,11,13,14,17	16,17	- - -	8,14,15	- - -

Wetzel Grid

In all three categories of the various body measurements, the serum ascorbic acid and serum carotenoids decreased with age. In Table 87 are presented the ages when the lowest concentrations of serum ascorbic acid and serum carotenoid occurred. If the maximal mean concentration in serum alkaline concentration marks the beginning of puberty for the group, then the minima in the other blood constituents in the next four years may indicate that the blood constituents are being utilized at a rapid rate in the body processes which accompany the pubertal changes.

Further evidence that the body utilizes these blood constituents at a rapid rate by growth was the precipitous drop in the serum ascorbic acid and serum carotenoid concentrations made by the boys and girls who were the tallest, heaviest and developing most rapidly. Furthermore, in the groups of average height, weight or developmental level, the decrease of the blood constituents with age was less marked at periods of rapid growth. In the slowly developing children these changes were less noticeable than in the average or rapidly developing children. The changes in blood levels with age could not be explained by low dietary intakes. The mean concentration of serum alkaline phosphatase were about the same at the various age-sex groups whether classified according to height, weight ot developmental level. However, it appeared from the data

Table 91

Ages When Minimal Mean Concentrations of Serum Ascorbic Acid and Serum Carotenoid Occurred, also When the Maximal Mean Concentration of Serum Alkaline Phosphatase Occurred

	Serum ascorbic acid		Serum carotenoid		Serum alkaline phosphatase	
	boys	girls	boys	girls	boys	girls
Weight						
Heaviest	14	14	15	13	12	11
Average	15	15	15	13	13	12
Lightest	15	15	15	12	14	12
Height						
Tallest	14	13	15	16	12	11
Average	15	15	15	15	14	11
Shortest	15	16	13	16	13	12
Developmental level						
Highest	14	13	15	13	12	10
Average	15	13	15	13	13	11
Lowest	13	15	13	12	13	12

on the extreme groups that serum alkaline phosphatase was more related to height and developmental level than it was to weight.

Only two consistent relationships were noted between body measurements and hemoglobin concentration in the blood of boys and girls. The boys who were shortest, lightest and of lowest developmental level tended to have lower hemoglobin concentrations than the other two groups of boys. However, the girls who were tallest, heaviest and developing rapidly tended to have lower hemoglobin concentrations in the blood after 13 years than before 13 years. These observations may be a reflection of the poor intakes of protein, iron, riboflavin and niacin of the older girls.

From this study of the relationship of height, weight and developmental level with dietary intakes and blood constituents it may be concluded that the different rates of growth tend to be associated with nutrient intakes and concentrations of various blood constituents.

Interrelationships among the Various Blood Constituents of Iowa Children and Physical and Nutrient Intakes

The mean serum ascorbic acid, serum carotenoid, and serum alkaline phosphatase concentrations and hemoglobin concentrations in the blood of rural and urban children for each age-sex groups were presented in Tables 52, 60, 67, 76 and 77.

These data show that the serum ascorbic acid and carotenoid concentrations decreased with age to the minima at 15 years for the boys in both blood constituents and 13 years in carotenoid concentration and 15 in ascorbic acid concentration for the girls. These low concentrations occurred after the age when the mean maximum concentration in serum alkaline phosphatase concentration had been attained (11 years for girls and 13 years for the girls).

The relationship between the various blood constituents and other measurements of nutritional status was most evident when each age-sex group was subdivided into groups with the highest, with the lowest and with the average concentrations.

From 6 to 13 years the boys and girls with the highest serum ascorbic concentration tended to be slightly taller than the boys and girls of corresponding ages with the lowest serum ascorbic acid concentrations. The boys from 6 to 12 with the highest serum carotenoid concentrations tended to be taller than the boys with low concentrations. There was no consistent relationship between weight and developmental level and the classification of the blood constituent.

For the children with highest and average serum alkaline phosphatase concentrations, within the year in which they made the greatest increase in height, they attained the highest mean serum alkaline phosphatase concentration. The significance of the level of serum alkaline phosphatase concentration in relation to physical development varies with age under consideration. For older children the higher levels may mean delayed maturation.

There was no relationship evident between the level of serum alkaline phosphatase concentration and the diets of the three groups of boys and girls. Neither was the hemoglobin concentration related to nutrient intake when means of children with high, low and intermediate concentrations were compared with their respective mean daily intakes.

The boys and the girls with highest or lowest serum concentrations of serum ascorbic acid and serum carotenoid did tend to reflect the dietary intakes.

The girls and boys who had highest serum concentrations of ascorbic acid and of carotenoids had diets with higher contents of protein, minerals and vitamins than had the children with the lowest concentrations of these two substances.

The lowered serum concentrations of ascorbic acid and carotenoids at certain ages during puberty cannot be wholly accounted for by the dietary intake. The children in the lowest concentration groups did not have intakes of ascorbic acid and carotenoids that would be expected to result to such low serum concentrations. Storvick and her co-workers (1947, 1950) observed that intakes of ascorbic acid equal to the recommended allowances did not support tissue saturation. In view of the findings of Storvick and her associates and of this study the need of these two nutrients during puberty should be reevaluated.

From the observations on the data of Iowa children a satisfactory serum concentration of serum ascorbic acid or serum carotenoids was not the same at all ages and in both sexes. Therefore, a single standard of serum ascorbic acid concentration and serum carotenoid concentration should not be used for all ages.

Of the four blood constituents, serum ascorbic acid and serum carotenoid concentration were more closely related to each other than any of the other blood constituents. The relationship of serum ascorbic acid and serum carotenoid concentrations can be expected within a living organism since in nature the two vitamins are often associated with each other, as in fruits and vegetables.

SUMMARY

Approximately 1200 boys and girls were chosen randomly to represent the Iowa children who attended various types of public schools. In the group were included urban elementary schools, small town elementary schools and junior and senior high schools, and consolidated and independent schools with grades one to twelve. A series of physical and biochemical measurements were made on these children to determine their nutritional status. A seven-day dietary record was obtained from each child.

The results of the study of nutrient intake, body measurements, and blood constituents have been summarized at the close of preceding sections. In brief, relationships between physical growth, nutrient intake and blood constituents were studied. In this analysis the children were subdivided into three groups based on their physical measurements and blood constituents:

The most outstanding results of the study were, as follows:

1. Boys had mean daily intakes of food energy and of nutrients which either exceeded or approached the allowances, except for calcium. Girls from 6 to 13 years had mean daily intakes of food energy and of nutrients which either

approached or exceeded dietary allowances of the National Research Council, except for calcium and iron. After 13 years of age the girls had intakes of protein, thiamine and riboflavin, in addition to calcium and iron, which were generally below the allowances. The values of the other nutrients fluctuated about the allowances.

2. The physical measurements showed that the children in this study made continuous, though irregular, yearly gains in height and in weight. Since the height and the weight data in this study were representative of a large population of reasonably well-nourished and healthy children, they may be used as a standard of reference for the heights and weights of other Iowa children. The measurements were similar to those made in other mass studies of Iowa school children living in specific communities.

3. Height, weight and developmental levels of boys throughout the school age and of girls from 6 to 13 years tended to be related to nutrient intake, as shown by the differences in the nutrient value of the diets of the highest and lowest groupings according to physical measurements.

4. The boys and the girls from 6 to 13 years, who were either the tallest, heaviest or developing rapidly or who were average in height, weight and developmental level had diets which exceeded or conformed to the allowances in nutritive value. The girls and boys who were shortest,

lightest and developing slowly and the girls from 13 to 18 years who were tallest, heaviest and developing rapidly, usually had intakes less than the allowances. This analysis suggested that the allowances are more applicable to the intakes of Iowa children who were average or above in physical development than to those who were below average.

5. Serum ascorbic acid and serum carotenoid concentrations apparently reflected not only dietary intake, but also the rate at which the children were developing or growing. The serum concentrations of both blood constituents decreased with age to a low level at 13 to 15 years. The decrease was precipitous for the rapidly growing children; it was less marked for the average groups, and scarcely evident for the lowest. Regardless of classification the decrease was most evident at periods of rapid growth. For the boys the concentrations of serum carotenoids were negatively correlated with age and positively correlated with the vitamin A value of fruits and vegetables present in the diet. When the intake and age of the boys were considered together in a multiple regression, the relationship between intake, age and concentration was highly significant. These relationships were not tested for girls.

6. The changes in the mean serum concentrations of serum ascorbic acid or carotenoids from year to year through the school ages, suggested the need of a standard of

reference at each year, rather than for school children in general.

7. This study did not reveal a relationship between dietary intake and concentration of serum alkaline phosphatase. Before puberty, boys and girls of the most advanced physical development tended to have higher serum alkaline phosphatase concentrations than the children in the lowest; the children of the average groupings tended to have intermediate values at these ages. After puberty the serum alkaline phosphatase concentrations of rapidly growing children and of average children declined toward the low concentrations, characteristics of adulthood, earlier than the slow growing children.

8. In the average groups according to various physical measurements the well-defined peak in the mean serum concentration of serum alkaline phosphatase preceded the marked depression in the serum concentrations of ascorbic acid or of carotenoids by one to two years. These changes did not occur in the lowest group.

9. Concentration of hemoglobin in the blood of Iowa boys was highly correlated with the mean daily intakes of protein, niacin, riboflavin and iron. Yet, among the boys age was more highly correlated with hemoglobin concentration in the bood than were these nutrients. The boys of lowest

group of physical measurements tended to have lower hemoglobin concentrations than did the boys of the other two groups. Contrary to the boys, the girls from 13 to 18 years of the highest group in physical measurements had lower hemoglobin concentration than the other two groups.

This method of analyzing data used in the present investigation was exploratory. The results from these analyses suggest the need of further study of the nutritional status of children who are maturing at different rates.

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This study is part of North Central Region Cooperative project NC-5, Nutritional Status and Dietary Needs of Population Groups, subproject No. 2 -- "The Nutritional Status of School Children: The School Lunch as an Influencing Factor."

APPENDIX

Table 92

Population Group One

Schools in Cities of 50,000 Population or Over

	Junior and senior high schools					Elementary school				
City	Total	Full meal	Supp. meal	No lunch	No information	Total	Full meal	Supp. meal	No lunch	No information
C.R.	4	4	--	--	--	15	1	--	14	--
D.	4	--	3	1	--	13	--	--	13	--
D.M.	10	10	--	--	--	45	3	--	42	--
W.	5	5	--	--	--	14	--	6	8	--
S.C.	7	7	--	--	--	23	--	--	23	--
Total	30	26	3	1	--	110	4	6	100	--

Table 93

Population Group Two

Schools in Cities and Towns 1 - 49,999 Population and All Consolidated and Independent Schools with Grades 1 to 12

Type of lunch program	Total	Full meal	Supp. meal	No lunch	No information
Schools					
Junior and senior high	86	41	17	28	--
Elementary	259	26	130	103	--
Consolidated and independent	783	525	33	209	16
Total	1128	592	180	340	16

Table 94

Population Group Three

Rural Elementary Schools

Type lunch program	Counties[a]
Some food	61
No food	10
No information	28
Total	99

[a]It was not possible to classify the numerous rural schools under each category for type of lunch program, so the schools were divided by counties into the following groups: (1) some type of lunch, (2) no food served, (3) no information about the school.

Table 95

Schools in First Sample

I. Population Group I -- schools in cities of 50,000 or over

A. Junior and senior high schools

1. Full meal

McKinley (Cedar Rapids)
West Waterloo

2. Supplemental food

Frank Smart (Davenport)
J. B. Young (Davenport)

3. No lunch

None

4. No information

None

B. Elementary schools

1. Full meal

Phillips (Des Moines)
Willard (Des Moines)

2. Supplemental food

Roosevelt (Waterloo)
LaFayette (Waterloo)

3. No lunch

Buchanan (Cedar Rapids)
Cleveland (Cedar Rapids)

4. No information

None

Table 95 (Cont'd)

II. Population Group II -- schools in towns under 50,000 and consolidated and independent schools with grades 1 to 12

A. Junior and senior high schools

1. Full meal

Oak Street (Burlington)
Iowa City

2. Supplemental food

Oelwein
Stuart (Ottumwa)

3. No lunch

Mason City
Oskaloosa

4. No information

None

B. Elementary schools

1. Full meal

Roosevelt (Perry)
Richardson (Fort Madison)

2. Supplemental food

Grimes (Burlington)
North Ward (Sigourney)

3. No lunch

West Lynns (Clinton)
Grant (Albia)

4. No information

None

Table 95 (Cont'd)

C. Schools with grades 1 - 12

1. Full meal

Slater
Farnhamville

2. Supplemental food

Jessup
DeWitt

3. No lunch

Elvira
Buffalo

4. No information

Eureka
Brighton

III. Population Group III

A. Rural elementary schools

1. Some type of food

Clinton County
O'Brien County

2. No food served

Carroll County
Des Moines County

3. No information

Bremer County
Winnebago County

Table 96

School in Sample

Population Group II -- Consolidated and independent schools with grades 1 to 12

1. Full meal

Slater
Farnhamville
West Branch
Henderson
Armstrong
Cumberland
Viola Township
Napier
Nodaway

2. No lunch

Humeston
Woden
McGregor
New Hampton
Fredrickburg

Note: The following schools did not wish to participate in the study: Woden, Nodaway and Henderson. The schools were randomly replaced by Corwith, Attica and Williams.

Table 97

Schools in the Sample

Population Group I -- Schools in cities of 50,000 population or over

A. Senior high schools

1. Full meal

East (Des Moines)
North (Des Moines)
McKinley (Cedar Rapids)
East (Waterloo)

2. No lunch

Davenport

B. Junior high schools

1. Full meal

Amos Hiatt (Des Moines)
Wilson (Des Moines)
Wallace (Cedar Rapids)
McKinley (Cedar Rapids)

2. No lunch

Sudeon (Davenport)

C. Elementary schools

1. Full meal

Phillips (Des Moines)
Hayes (Cedar Rapids)
Arthur (Cedar Rapids)

Table 97 (Cont'd)

Population Group I -- Schools in cities of 50,000 population or over
2. No lunch Wallace (Des Moines) Longfellow (Des Moines) Roosevelt (Waterloo) Irving (Waterloo) Emerson (Waterloo) Buchanan (Cedar Rapids) Joy (Sioux City) Lincoln (Davenport)

Table 98

Population Group II -- Schools in towns with populations 49,999 and under

A. Junior and senior high schools

1. Full meal

Charles City
Clear Lake
Council Bluffs
Iowa City

2. No lunch

Boone
Cedar Falls
Maqhoketa

B. Elementary schools

1. Full meal

Emerson Hough (Newton)
Bryant (Algona)
Stewart (Washington)
Garfield (Cherokee)
Hawthorne (Independence)
Lincoln (Perry)

2. No lunch

Bryant (Boone)
Rogers (Marshalltown)
Crawford (Ames)
Garfield (Oskaloosa)
Agassiz (Ottumwa)
Jackson (Dubuque)
Garfield (Keokuk)
Franklin (LeMars)
McKinley (Mason City)
North (Sigourney)

Table 98 (Cont'd)

Population Group II -- Schools in towns with populations 49,999 and under

Roosevelt (Clinton)
Grant (Atlantic)
Whittier (Ames)
Sunnyside (Burlington)
Grant (Albia)
Franklin (Creston)
Franklin (Council Bluffs)
Grimes (Burlington)
Grades (Decorah)
Hawley (Fort Dodge)

Note: The following schools did not wish to participate in the study: Grimes, Sunnyside, Grant (Atlantic). They were randomly replaced by Cedar Heights (Cedar Falls), Manu and Sabin (Iowa City).

Table 99

Schools in the State-wide Sample and the Number of Children in the Sample

Population groups	Program	Total no. schools	No. schools in sample	School enrollment no. boys	School enrollment no. girls	Children in sample no. boys	Children in sample no. girls
I 50,000	Lunch[a]	11	3	381	364	18	17
	No lunch[a]	11	3	326	298	18	18
	No lunch	95	8	1165	1088	48	49
II 50,000	Lunch[a]	37	6	177	212	33	33
	No lunch[a]	37	6	585	526	36	37
	No lunch	219	20	2438	2296	117	122
II Grades 1 to 12	Lunch	525	12	1124	1044	165	177
	No lunch	242	5	700	656	82	84
II Jr. and Sr. high school	Mixed	62	7	2375	2427	79	80

[a]Two sets of samples were drawn from these schools: (1) from the group who regularly ate the school lunch; (2) another from the group that went home or carried lunch.

Dear Parents:

One of the most important factors contributing to the health of children is the food they eat. We now know that the way they eat not only influences how they grow and develop physically, but also how well and how quickly they learn. Iowa State College is launching a state-wide program to find out how the children of Iowa are eating and if their health is as good as it is possible for them to have through good nutrition. Iowa and several other states are working together to find the answers to these questions. Several schools, about 40, have been selected at random throughout the state. By studying a sample of children from all of these schools we shall arrive at the facts about Iowa school children.

A group of trained workers from Iowa State College will visit each of the sample schools which are willing to cooperate and secure some dietary records of the children, take heights and weights and other body measurements, and make blood tests for hemoglobin (the material that makes blood red) and for Vitamin C. Possibly the pupils will be given medical and dental examinations by well qualified doctors and dentists.

Since we cannot offer to all the students the opportunity of receiving all the examinations, tests, and the analysis of a week's dietary intake, we have selected a few students whose names were drawn from the group to represent the school population. Your child has been selected.

If you are willing to have your child included in this study, will you please indicate by signing the enclosed form. The results of the medical and dental examinations and the nutritional study will be made available to you if you desire. You will be told in advance of the dates that the examinations will be made.

Sincerely,

F-696

I wish to cooperate in the study of Iowa School Children which is being conducted. Will you please give medical and dental examinations and laboratory tests to:

Howard Mullins

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Signed by ______________________
(Father)

Mrs. Leonard Mullins
(Mother)

____
(Guardian)

Will you please enclose this form in the envelope addressed to Virginia De Cecco, Research Associate.