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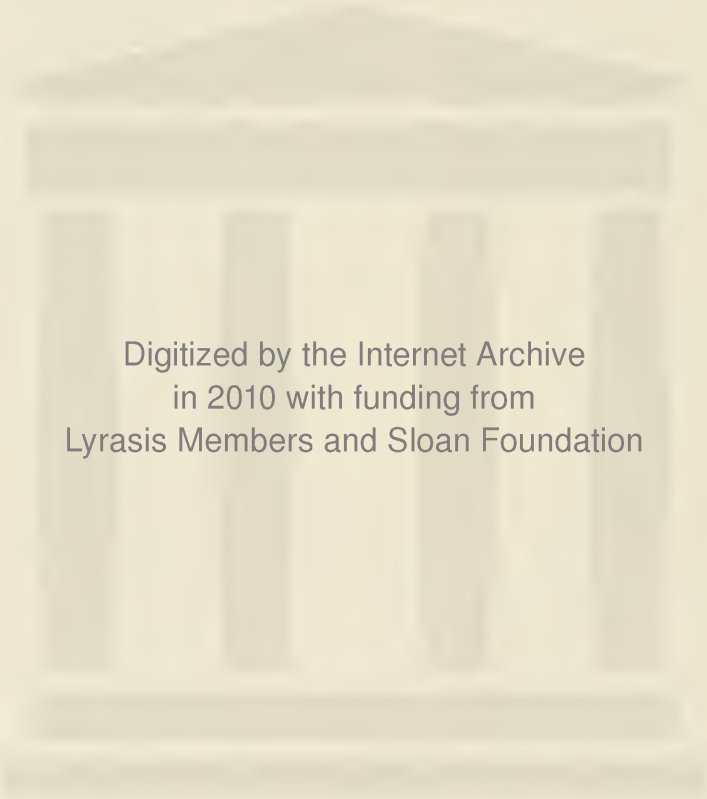

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A Nutrition Study of West Virginia Students

by

Hazel C. Cameron

Agricultural Experiment Station
College of Agriculture, Forestry, and Home Economics
West Virginia University
C. R. ORTON, Director
Morgantown

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VITAMIN A in large amounts was found to shorten significantly the average duration of common colds among students at West Virginia University in 1932-1934, whether the vitamin was obtained from food or from vitamin-rich oils (4). Shibley and Spies reported a similar finding among doctors and nurses in 1934 (10).

Such observations suggest that the body reserve of vitamin A was low in these subjects; and biophotometer tests on students in nutrition classes at the University have revealed at times a fairly large proportion having low vitamin A reserves. From a small group of 42 in 1939-40, 15 students gave results low or borderline. In each case the test was raised when the diet was improved by the addition of more milk, or of green vegetables, or of some non-food source of the vitamin. Such figures are in line with the findings of Stiebeling and Phipard (11) on employed wage earners and clerical workers in cities, where diet study indicated that only about one-third of the families received enough vitamin A to insure good visual adaptation.

Iron, too, has often been found low in diets. The study of Stiebeling and Phipard indicated that only about one-half of the diets investigated supplied adequate amounts of iron according to present standards. In a study of food-consumption habits in Iowa farm families by Nelson, Hoyt, McLaughlin, and Morgan (8) iron intake tended to be low, and when cooking losses are taken into account, deficiency in iron may be marked. In Florida (1) 40 percent of 5,000 rural school children examined were found to be anemic, a condition which is usually considered to reflect a dietary deficiency of iron. Simple anemia has been found to be rather common among students in nutrition classes at West Virginia University.

Such signs of poor nutrition and dietary deficiencies indicated need for study of nutritional condition in students and gave rise to the present study of students at the University. Other states had already undertaken such studies, a master project on the nutritional status of college women having been outlined for the North-central States and a regional study of vitamin C metabolism in college students for the Northwestern States.

Such studies now offer greater promise of usefulness, since newer methods are available for assessing nutritional status (6, 7). In early studies, absence of obvious physical defects and the use of one of the scales measuring height-weight relationship were the chief means of evaluating nutritional states. More recently, anthropometry has been employed as well as X-ray studies for detecting the degree of calcification in bones, along with chemical tests of blood and urine and visual tests for vitamin reserves. These newer methods give promise of more accurate comparison and diagnosis of specific deficiencies. Simultaneous study of the diet eaten by the subjects studied, particularly with reference to the mineral and vitamin content, would help to relate the physical and chemical findings with specific dietary needs.

PROCEDURE

In the present study only a few of the newer diagnostic methods were available, but it was deemed advisable to begin a small study. Physical examination of the students on entrance to the University served to rule out obvious physical defects. Vitamin A reserve was measured by means of a visual biophotometer in a darkroom. The limitations in accuracy of this instrument, in detecting mild degrees of vitamin A deficiency, are well known; however, it is believed capable

*Deceased May 6, 1943

of detecting gross deficiencies, and in this study the instrument gave an excellent opportunity for taking a food history on each student. Blood study included hemoglobin, red-cell count, and hematocrit determination for proportion of cells to plasma.

One hundred first-year students, equally divided between men and women, were selected for study in the fall for each of two years (1939-40 and 1940-41). Selection was at random as students passed through the examining line at the Student Health Center, except that an effort was made to see that the group chosen included representatives of different colleges and students living at home and in fraternities or sororities as well as in dormitories. Blood samples were taken by venipuncture, using a definite amount of anti-coagulant (potassium oxalate). Hemoglobin determinations and red-cell counts were made on this blood within 24 hours, for which period the blood had been shown to be stable. Red-cell counts were made in duplicate or quadruplicate, with standard blood-counting pipettes checked against a certified pipette, using freshly filtered normal saline as a diluent. Wintrobe hematocrit tubes centrifuged for one-half hour at 3000 r.p.m. were used to determine proportion of cells to plasma.

A repeat blood count and hemoglobin determination was made in the winter on all subjects who could be reached and again in the spring when possible. For these blood counts a freshly flowing drop of capillary blood from finger or ear lobe was used.

Hemoglobin determinations were made by reading a 1-400 aqueous dilution of each oxalated blood sample in a Kuder photoelectric colorimeter. Hemoglobin values corresponding to these scale readings were read from a curve previously constructed, in which aqueous dilutions of 10 normal blood samples were plotted against hemoglobin values for the same bloods, calculated from blood-iron determinations. Since hemoglobin is believed to contain 0.33 to 0.34 percent iron, the weight (grams) hemoglobin per 100 ml. of blood was obtained by dividing the weight (milligrams) of iron per 100 ml. by 0.335.

The method found most satisfactory for determining the iron in blood was the colorimetric KCNS method of the Association of Official Agricultural Chemists (3). The curve was based upon iron determinations on ashed samples of blood by this method. Preliminary work with the thiocyanate-persulfate method described by Andes and Northup (2) (a modification of the method of Wong) (13) had given variable results. In this method it has been shown that the concentration of acids and salts affects the color reaction with KCNS (9), but even with standard amounts of reagents, including persulfate, temperature appeared to exert considerable influence upon the results during the short time required for the color to be developed and read.

The ortho-phenanthroline method for iron described by Hummel and Willard (5) gives clear-cut, consistent readings which do not fade within the time required for a reading; but the hemoglobin values calculated from iron determinations on blood by this method were higher than values usually given as normal (18 grams or more per 100 cc. of blood). Spectrophotometric readings on iron solutions of known concentration, using the o-phenanthroline method, were consistent at wave lengths of 540-550 and 555, giving no indication that the o-phenanthroline was developing color with some substance other than iron. Ashed samples of pure hemoglobin with an analysis of 0.3 percent iron gave a comparable percentage of iron by the o-phenanthroline and KCNS methods (0.298 and 0.297), which checks with the theoretical factor of 0.33 percent iron. However, on ashed blood, hemoglobin values based on iron determinations were consistently higher when o-phenanthroline was used than when KCNS was used to develop color. This suggests that whole blood may contain some iron not combined as hemoglobin, or some substance which retards maximum color development with KCNS.

TABLE 1 — RED-CELL COUNT OF 100 STUDENTS

Year	MEN				WOMEN			
	Cases tested	Average count	Below 5 million*	Increased by 300,000 or more	Cases tested	Average count	Below 4½ million†	Increased by 300,000 or more
1939-40	(*number*)	(*millions*)	(*percent*)	(*percent*)	(*percent*)	(*millions*)	(*percent*)	(*percent*)
Fall	63	5.47	16.7		43	4.27	60.4	
Winter	58	5.61	6.7	37.7	53	5.05	9.3	69.4
1940-41								
Fall	41	5.05	43.9‡		48	4.57	41.6	
Winter	47	5.61	2.1	72.3‡	46	4.92	13.0	46.5
Spring					40	4.95	10.0	20.0

* Normal value for red-cell count for men.
† Normal value for red-cell count for women.
‡ See text for explanation.

RESULTS

The results of the blood study for the two years are summarized in Tables 1, 3, and 4, and the biophotometer tests in Table 5.

From Table 1 it is evident that the average red-blood count for the men was above normal for the fall and winter in both years; for the women, above normal except in the fall of 1939, and this not far below. The percentage (16.7) of men whose hemoglobin fell below normal in 1939 was small, and this had dropped in winter to 6.7. The percentage of men below normal in the fall of 1940 was probably not so high as the figure shown in the table. A change in technicians for one day during the taking of the blood samples resulted in slight clotting in some instances. All bloods containing visible clots were discarded; but undoubtedly some with only slight clotting were counted, giving values lower than the true figures and a correspondingly high percentage below normal. The low figure in winter bears this out.

TABLE 2 — HEMOGLOBIN VALUES FOR NORMAL BLOOD

SOURCE	WEIGHT IN GRAMS PER 100 CC. OF BLOOD			
	MEN		WOMEN	
	(*range*)	(*average*)	(*range*)	(*average*)
Howell*		14		
Hawley & Maurer-Mast†	13-16	14.5	12-14	13
Hawk‡		15.6		
Osgood & Haskins**	14-18	15.8	12,15.5	13.8

* Textbook of Physiology. 13th ed. Saunders, 1938.
† Fundamentals of Nutrition. Charles C. Thomas, 1940. (Values below 12 and above 18 considered pathological.)
‡ Practical Physiological Chemistry. 10th ed. Blakiston, 1931. (This value considered most acceptable; 13.8 and 16.9 also given.)
** Arch Int. Med. 39 (1937), 643-55. (These values not necessarily given as optimum.)

TABLE 3 — HEMOGLOBIN VALUES OF 100 STUDENTS

Year	MEN						WOMEN					
	Cases tested	Range in gms. /100 ml. blood	Average gms. /100 ml. blood	14-18 gms. range		Improved	Cases tested	Range in gms. /100 ml. blood	Average gms. /100 ml. blood	12-15.5 gms. range		Improved
	(*number*)			(*number*)	(*percent*)	(*percent*)	(*number*)			(*number*)	(*percent*)	(*percent*)
1939												
Fall	39	13.00-18.75	15.49	36	92.3		34	12.03-15.43	13.63	33	97.0	
Winter	39	13.13-19.20	16.33	30	76.9	62	29	11.56-15.14	13.73	28	96.5	44
1940												
Fall	44	12.28-18.05	15.91	40	90.9		50	10.52-16.65	13.89	47	94.0	
Winter	35	11.53-18.00	15.84	33	94.3	30	43	10.80-17.00	14.36	29	67.4	55
Spring							40	10.42-16.84	14.10	31	77.5	38

TABLE 4 — HEMATOCRIT VALUES OF 100 STUDENTS

	FALL 1939		FALL 1940	
	Number tested	Value (percent)	Number tested	Value (percent)
Men	66	45.1	30	41.7
Women	45	38.9	47	39.2

A relatively large percentage of women (60.4 in 1939 and 41.6 in 1940) had red-blood counts below normal. This is in line with the more frequent occurrence of anemia in women than in men. In no case was the blood count low enough to be considered pathological; in all cases low counts improved in winter or spring, and in all except a very few the improvement brought the count to the normal level.

Various values have been given as normal for hemoglobin in blood as shown in Table 2.

The average hemoglobin values found in this study for the two years for both men and women reach or exceed these normal values; and, as seen in Table 3, from 75 to 97 percent of values fall within normal range. Most of the values which did not fall in this range exceeded it.

Hematocrit readings in Table 4 indicate a normal volume of red-cells for the men, according to the usually accepted standard of 40-45 percent cells. On this basis, the figures for the women in this study are slightly low. Somewhat higher average values are given by Wiehl (12) for Jewish boys 17-18 years of age and for girls of 17 in high-income families, values for the boys being 49 percent and for the girls, 44 percent.

Results of the biophotometer tests are given in Table 5, which follows.

TABLE 5 — BIOPHOTOMETER TESTS FOR VITAMIN A RESERVES IN 100 STUDENTS

Year	MEN		WOMEN	
	Number tested	Percentage low or borderline	Number tested	Percentage low or borderline
1939-40				
Nov.-Jan.	59	11.7	59	5.0
1940-41				
Nov.-Dec.			48	0.0
Jan.-Mar.	48	0.0		
1941-42				
Sept.-Oct.	54	0.0	55	0.0

DISCUSSION

The extent of variation from normal found in the red-cell counts is what might be expected in a group of normal students. Any marked departure from normal would be a reflection of a pathological condition rather than a dietary deficiency. The improvement which occurred during the school year, however, suggests some effect from a better diet or from better habits of eating.

While the average hemoglobin values in this study reach or exceed values for normal blood previously published, more significant than the actual values found is the evidence of improvement during the school year. Thus, in 1939,

62 percent of the men and 41 percent of the women showed improved hemoglobin values. In 1940, 30 percent of the men and 55 percent of the women showed such improvement. In other words, from one-third to two-thirds of the students in this study showed an increase in hemoglobin in winter or spring (or both) over the fall reading. Such increase in hemoglobin is usually taken to indicate an improvement in diet, either in iron content, or iron and copper, or, according to more recent evidence, perhaps in other mineral or vitamin factors of a well-rounded diet.

Improvement in food habits alone might bring about such improvement. Students eating in groups tend to forget food prejudices and so eat a better-balanced diet. From the food history taken on each student, it appeared that from 40 to 60 percent of the men had no marked food dislikes but "ate everything." The nutritional condition of these men would then reflect the quality of the diet available. Food prejudices were somewhat commoner among women than among men; only 30 to 40 percent of the women were omnivorous.

Of the iron-rich foods, liver was the most unpopular, with one-fourth of the students expressing a dislike for it. Eggs were generally well eaten by men but were refused by 6 to 13 percent of the women. Less than 10 percent of the students expressed dislike for spinach or prunes.

Bread was eaten in considerable quantity, especially by men, the average being 7 to 8 slices a day for men and 5 for women. However, approximately twice as much white bread was chosen as whole wheat (according to the students' statement). Since at the time of this study bread was not enriched, bread therefore contributed little iron to the diet.

Milk, of course, contributes little iron but it does furnish essential food factors which may be among those which influence the body's use of iron; hence the quantity consumed is of importance in such a study as this. As a whole, the men drank more milk than the women, their average being more than 3 glasses daily; for the women it was slightly over 2. From 75 to 90 percent of all men drank 2 or more glasses daily, and 50 to 60 percent of the women. The women showed greater tendency to avoid milk as a "fattening food."

The percentage of biophotometer tests showing low or borderline cases is lower for the 118 students tested in 1939-40, as might be expected, than for the smaller number of students tested in nutrition classes. It is lower, too, than the figures given in the study of Stiebeling and Phipard on clerical workers. The somewhat greater use of green and leafy vegetables by the women, as indicated by their food histories, may account for the smaller percentage of low or borderline vitamin A tests among women than among men.

Lack of any subnormal results for the year 1940-41 led to the question whether the biophotometer tests were being taken so late in the school year that they reflected changed food habits rather than the customary food habits of the students. Tests were therefore made on 109 additional students early in the fall of 1941-42, before habits of eating had changed enough to affect the vitamin A reserve. These again fell within normal range. It would appear, therefore, either that increasing attention to the importance of nutrition in recent years had resulted in selection of better diets, with consequently greater vitamin A reserves, or that some change had taken place in the biophotometer, rendering it less sensitive to mild degrees of vitamin A deficiency.

SUMMARY

In measuring nutritional condition, blood studies including red-cell count, hemoglobin, and hematocrit values were made on approximately 200 first-