6-1961

Concentration of Selected Constituents in the Blood of Healthy Women 30 to 90 Years of Age in Six North Central States

Ruth M. Leverton

Jean Pazur

North Central Regional Publication 121

Concentration of Selected Constituents in the Blood of Healthy Women 30 to 90 Years of Age in Six North Central States

Nebraska
Research Bulletin
198

June 1961

University of Nebraska College of Agriculture
The Agricultural Experiment Station
E. F. Frolik, Dean; A. W. Epp, Acting Director

Agricultural Experiment Stations of Illionis,
Iowa, Michigan, Minnesota, Missouri,
North Dakota, South Dakota, Nebraska,
Wisconsin, Ohio, and Kansas.

This bulletin is Contribution No. 26 from Subproject 1, "The Nutritional Status and Dietary Needs of Older People" of North Central Regional Cooperative Project NC-5, "Nutritional Status and Dietary Needs of Population Groups". The Bureau of Human Nutrition and Home Economics of the U. S. Department of Agriculture cooperated in this project.

AUTHORS

Ruth M. Leverton, Jean Pazur—Nebraska Agricultural Experiment Station

Marian Tolbert Childs, Alice Forsythe Carver, Janice M. Smith—Illinois Agricultural Experiment Station

Harriett Roberts Wilkinson, Isabel Pesek, Pearl P. Swanson—Iowa Agricultural Experiment Station

Wilma D. Brewer, Margaret A. Ohlson—Michigan Agricultural Experiment Station

Alice Biester, Marie B. Hutchinson—Minnesota Agricultural Experiment Station

Lida Burrill, Beth Alsup—South Dakota Agricultural Experiment Station

TECHNICAL COMMITTEE FOR COOPERATIVE NUTRITIONAL STATUS STUDIES IN THE NORTH CENTRAL AREA

Pearl P. Swanson and Ercel S. Eppright—Iowa Agricultural Experiment Station

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Margaret A. Ohlson—Michigan Agricultural Experiment Station

Alice Biester—Minnesota Agricultural Experiment Station

Margaret Mangel—Missouri Agricultural Experiment Station

Ruth M. Leverton—Nebraska Agricultural Experiment Station

Mary B. Patton—Ohio Agricultural Experiment Station

Lida M. Burrill—South Dakota Agricultural Experiment Station

May S. Reynolds—Wisconsin Agricultural Experiment Station

Esther L. Batchelder and Milicent L. Hathaway—Bureau of Human Nutrition and Home Economics, U. S. Department of Agriculture

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Issued June 1961, 3,000

INTRODUCTION

A cooperative regional research project entitled "The Nutritional Status and Dietary Needs of Population Groups" was in progress in 11 North Central States from 1946 to 1958. One of the population groups consisted of women who were 30 years of age or older. One phase of the biochemical measurements included the quantitative determination of the concentration of selected constituents in the blood. The results of the blood studies on the women who were subjects for this regional research project are reported in this bulletin.

When the investigation of nutritional status was begun in 1947, information about the quantitative values for the blood constituents of healthy women was meager. The standards for normal values which were given in the literature and textbooks then were chiefly averages of reports from many sources with great variation in the criteria used for selecting the "normal" person.

Most of the values had been obtained from hospital or office patients. For this reason, regional research workers who were studying nutritional status believed that the determination of certain blood constituents would not only aid in the interpretation of other nutritional data which they would be obtaining, but also would contribute to the general information about these blood values in healthy women.

The states which participated and the number of women on whom the different blood measurements were made are listed in Table 1. All blood values were not determined for every subject and every cooperating state did not determine values for each of the different constituents reported here.

PROCEDURE

Description of Subjects

It seems suitable to refer to the women who were subjects as "normal" or "healthy" in the customary use of the word as distinguished from women in poor health or under medical treatment for suspected or confirmed abnormalities or malfunctioning.

The criteria that each woman met in order to become a subject included the following:

She was 30 years of age or older (the women ranged in age from 30 to 92 years).

She lived in or near the city in which the Agricultural Experiment Station and the cooperating laboratory of her state were located.

She was interested in the study and cooperated in such a way that the results could give a picture typical of her dietary habits, blood values, and other aspects of health.

She was in apparent good health, experiencing a feeling of well-being and free from observable signs of disease or malfunction. (In Illinois and Nebraska results of thorough medical examinations were used to substantiate the selection.)

Table 1. Blood constituents determined for healthy women in 6 North Central States.

CONSTITUENT		Number of women studied in each state	
Hemoglobin		Illinois	94
		Iowa	94
		Michigan	101
		Nebraska	324
		South Dakota	85
		Total	698
Red cells		Illinois	94
		Iowa	95
		Michigan	15
		Nebraska	319
		South Dakota	85
		Total	608
Leukocytes			
Total		Iowa	93
		Minnesota	120
		South Dakota	85
		Total	298
Differential	Neutrophils	Iowa	82
	Lymphocytes	Michigan	8
	Monocytes	Minnesota	120
	Eosinophils	Nebraska	303
	Basophils	South Dakota	85
		Total	598
Differential	Neutrophilis		
	Segmented	Nebraska	303
	Band	South Dakota	85
	Metamyelocytes	Total	388
Serum protein		Illinois	94
		Iowa	59
		Nebraska	312
		South Dakota	52
		Total	517
Calcium		Nebraska	281
Phosphorus		Nebraska	281
Glucose		Nebraska	239

She was capable of assuming responsibility, consistent with her age, as a member of a household or as an employed person, or both.

Additional information about the subjects is given in Table 2. In five of the six states most of the women or their husbands were in the business or professional class and their socio-economic status was above average. In Michigan, however, the women were from a sample selected statistically to be a cross section of the area bounded by Lansing and East Lansing. There were only a few privileged women in this sample.

Table 2. Information about the subjects.

Item	Number of women	Percent
Women studied	818	
Women who had had children	676	82.6
Total number of children	1,845	.....
Women who had reached the menopause	513	62.7
Women who were full-time homemakers	652	80.0
Women who were employed full-time outside the home	102	13.0
Women who were employed part-time outside the home	64	7.8

Hemoglobin values were determined for 698 subjects from 5 states. All of the subjects for whom red cell count, serum protein, leukocyte (except for the Minnesota subjects), calcium and phosphorus, and glucose values were determined were from this group of 698 women. In addition, 120 subjects from Minnesota were included in the study of leukocyte values. The number of women in each age decade will be indicated in the tables of results.

The subjects came to the research laboratories in the morning for the blood tests. Usually this was on the same day that they came for their basal metabolism tests. Most of the tests were made in the fall, winter, or early spring months but the weeks around special holidays were avoided.

The blood samples were taken for analysis before the subject had breakfast, except in the case of Illinois subjects. These women had a small breakfast of toast and jelly, black coffee and sugar after their basal metabolism test and immediately before the blood samples were taken. Illinois and Nebraska workers used venous blood for all of the measurements and the Iowa workers used it for serum protein. Measurements made in the other states, or for other constituents in Iowa, were on capillary blood. Every precaution was taken in securing the blood samples to guarantee free flowing blood which was not diluted with tissue fluid from the finger prick, or stagnated in the vein by use of a tight tourniquet.

METHODS

Hemoglobin

The cooperating laboratories had been determining hemoglobin values routinely for sometime prior to the beginning of this regional study. Each had a method that was standardized by determining the oxygen capacity of hemoglobin (1,29), and that gave reproducible results in the hands of its trained personnel. For this reason, the workers in the cooperating states decided that each laboratory should continue using its established method. The nature of the colored compound which was developed from the hemoglobin and the intensity of which was measured in a photoelectric colorimeter, in the different

laboratories, together with the literature reference to the method are:

Illinois	alkaline hematin	(25)
Iowa	oxyhemoglobin	(7)
Michigan	alkaline hematin	(30)
Nebraska	oxyhemoglobin	(30)
South Dakota	cyanmethemoglobin	(32)

Red Cells

For counting the erythrocytes cells two standardized pipets were prepared with properly diluted blood. Hayem's solution (12) was used as the diluting fluid by all the states except South Dakota where Gower's solution (4) was used. The cells in four chambers were counted. Two chambers of a Spencer Improved Neubauer counting chamber were filled from each pipet and the counts of the four chambers were averaged and reported.

Leukocytes

Two or three standardized pipets were prepared from each subject's blood sample for determining the number of total leukocytes. The cells were counted in two chambers (Improved Neubauer) which had been filled from each pipet, and the four counts were averaged.

Wright's stain (31) was used in all states for the relative differential leukocyte count except in Iowa where Field's stain (8) was used. Duplicate slides were made and the number of cells counted varied as follows: Iowa 200, Michigan 100, Minnesota 600, Nebraska 800, and South Dakota 400.

The nomenclature and classification used for reporting the differential counts followed the recommendations of the Committee for Clarification of the Nomenclature of Cells (6).

Serum Protein

Values for serum protein were determined by the falling drop densitometric method in Illinois and South Dakota (19) and Iowa (3). The conversion of density to serum protein values was checked by determining the total nitrogen content of selected samples of serum (2). In Nebraska, serum protein was determined by analysis for total nitrogen by the Kjeldahl method (2).

Calcium and Phosphorus

Calcium was determined by the method of Sandroy (28). This included converting the calcium in the serum to the oxalate and titrating the oxalate with standardized potassium permanganate.

Inorganic phosphate was determined in the serum colorimetrically using the method of Fiske and Subbarow (9) to form a phosphomolybdic acid which was then reduced to phosphomolybdous acid. The concentration of reduced acid was read in an electric colorimeter which

was standardized with solutions of a known concentration of potassium phosphate (15).

Glucose Tolerance

The method of Hoffman (16) was used for determining the amount of glucose in blood. A known amount of potassium ferricyanide was added to the protein-free blood filtrate and the portion that was not reduced by the glucose was measured in an electric colorimeter (15).

Each subject came to the laboratory for the determination of basal metabolic rate, and following this a sample of fasting blood was drawn by venipuncture. Then the subject was given a solution of 100 gm of glucose dissolved in 250 ml of distilled water to drink. Venous blood samples were drawn ½ hour, 1 hour, and 2 hours after the ingestion of the glucose. Values were determined after 3 hours for some of the subjects studied but values secured did not seem to contribute any more to the interpretation of the results than the 2 hour values.

RESULTS

Hemoglobin and Red Cells

Values for the hemoglobin and red cell content of the blood of the women who were studied are summarized in Tables 3 and 4 respectively. For each constituent the mean and standard deviation are given for the women in each age group in each of the 5 states, for all of the women in each state, for all of the women in each age group in the 5 states, and for all of the women in all age groups in all of the states participating.

An analysis of variance test revealed no significant differences in the hemoglobin and red cell values among the different states.

Hemoglobin values for the 698 subjects ranged from 10.3 to 16.2 grams per 100 milliliters of blood with a mean of 13.3 ± 0.95 gm. The frequency distribution curve of the individual values is shown in Figure 1. Sixty percent of the cases were between 13.0 and 14.0 gm per 100 ml and 75 percent of them between 12.5 to 14.0 gm.

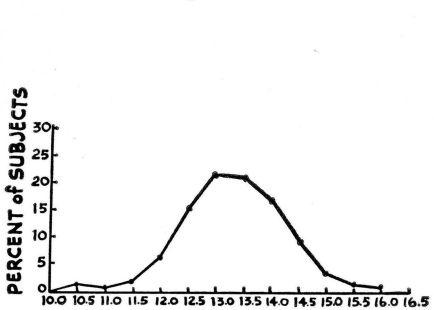

Figure 1. Distribution of hemoglobin values of 698 women.

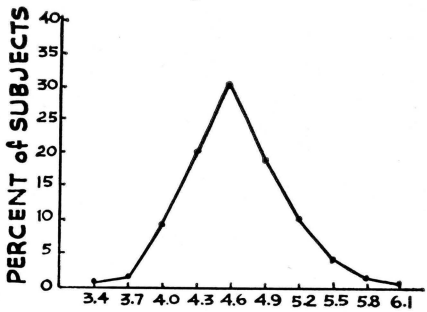

Figure 2. *Distribution of red cell* values of 608 women.

Table 3. Mean hemoglobin values of women of different ages and living in 5 North Central States.

Age group	Illinois	Iowa	Michigan	Nebraska	South Dakota	All states
30-39 years						
No. subjects	30	18	.....	62	12	122
Mean gm/100 ml	13.0	13.0	.....	13.1	13.3	13.1
S. D.[1]	.88	.95	.....	.94	.63	.90
40-49 years						
No. subjects	24	28	19	104	12	187
Mean gm/100 ml	13.0	13.5	13.2	13.1	13.7	13.2
S. D.	.55	.78	.92	.89	1.28	.89
50-59 years						
No. subjects	12	24	30	102	21	189
Mean gm/100 ml	13.0	13.9	13.8	13.2	13.5	13.4
S. D.	.63	1.20	1.17	.85	.70	.97
60-69 years						
No. subjects	20	12	24	43	13	112
Mean gm/100 ml	13.3	13.9	14.0	13.4	13.1	13.5
S. D.	.70	.68	1.19	.80	.66	.90
70-79 years						
No. subjects	5	11	25	13	18	72
Mean gm/100 ml	13.0	13.9	13.7	13.4	13.4	13.5
S. D.	.95	.66	1.04	.76	1.58	1.11
80-92 years						
No. subjects	3	1	3	.....	9	16
Mean gm/100 ml	13.6	12.2	13.7	.....	13.4	13.4
S. D.	.45	..	.61	.. ..	.91	.79
All ages						
No. subjects	94	94	101	324	85	698
Mean gm/100 ml	13.1	13.6	13.7	13.2	13.4	13.3
S. D.	.73	.97	1.11	.87	1.03	.95

[1] Standard Deviation

The red cell content of the blood of 608 subjects ranged from 3.3 to 6.2 million per cubic millimeter with a mean of 4.68 ± 0.47 million. In Figure 2 the frequency distribution curve shows that 70 percent of the subjects had values between 4.3 and 4.9 million per cmm and 90 percent between 4.5 and 5.2 million.

The mean values for hemoglobin and red cells for all subjects in each age decade from the different states appeared to increase slightly with advancing age, from 13.1 to 13.5 gm per 100 ml for hemoglobin, and from 4.58 to 4.95 m per cmm for red cells. Application of Students "t" test showed no significant difference between these values.

Iowa was the only state in which there was a significant difference among the age groups in the means for hemoglobin ($F = 2.98$) and for red blood cells ($F = 3.00$). Both values are significant at the 5 percent level of probability. The mean values for both hemoglobin and red cells for the 30-39 year group were significantly lower (5 percent level of probability) than for the older age groups, with the exception of the 40 to 49 year group in the case of hemoglobin.

Table 4. Mean red cell values of women of different ages and living in 5 North Central States.

Age group	Illinois	Iowa	Michigan	Nebraska	South Dakota	All states
30-39 years						
No. subjects	30	17	.....	60	12	119
Mean m/cmm	4.53	4.65	.....	4.53	4.89	4.58
S. D.[1]	0.39	0.45	.....	0.37	0.54	0.42
40-49 years						
No. subjects	24	29	1	103	12	169
Mean m/cmm	4.48	4.95	4.30	4.51	5.07	4.62
S. D.	0.40	0.39		0.33	0.59	0.43
50-59 years						
No. subjects	12	24	8	100	21	165
Mean m/cmm	4.43	5.09	4.77	4.57	4.88	4.68
S. D.	0.26	0.53	0.70	0.36	0.43	0.46
60-69 years						
No. subjects	20	12	4	42	13	91
Mean m/cmm	4.51	4.89	5.03	4.63	5.16	4.73
S. D.	0.32	0.41	0.20	0.39	0.41	0.43
70-79 years						
No. subjects	5	12	2	14	18	51
Mean m/cmm	4.34	5.14	5.25	4.49	5.11	4.88
S. D.	0.34	0.35	0.63	0.45	0.87	0.69
80-92 years						
No. subjects	3	1	.....	.....	9	13
Mean m/cmm	4.33	4.30	.....	.....	5.22	4.95
S. D.	0.39				0.52	0.62
All ages						
No. subjects	94	95	15	319	85	608
Mean m/cmm	4.43	4.83	4.83	4.54	5.05	4.68
S. D.	0.35	0.42	0.51	0.38	0.56	0.47

[1] Standard Deviation

Leukocytes

Total leukocyte counts were made for 298 subjects in 3 states, and relative differential leukocytes for 598 subjects in 5 states. In 2 of these 5 states relative differential neutrophil values were determined for 388 women. All of the cell counts were made on fasting blood (no food for the previous 14-16 hours). Values for all subjects in each age group in the different states have been combined in these tables because of the wide range in the counts for each type of leukocyte and the large standard deviations for the means. There were no significant differences in leukocyte values among the means for the different age groups.

Total Leukocytes

The mean and standard deviation for the women in each age group are given in Table 5. The mean for the 298 subjects of all ages was 6.40 ± 1.64 thousand per cubic millimeter. The frequency distribution

Table 5. Total leukocyte values of 298 women.[1]

Age group	Number of subjects	Leukocytes	
		Mean	S. D.[2]
years		thousands per cmm	
30-39	50	6.68	1.73
40-49	61	6.66	1.80
50-59	65	6.04	1.38
60-69	44	6.01	1.52
70-79	48	6.21	1.61
80-97	30	7.03	1.49
All subjects	298	6.40	1.64

[1] In Iowa, Minnesota, and South Dakota.
[2] Standard Deviation.

curve in Figure 3 indicates that 80 percent of the cases were between 4.5 and 7.5 thousand per cmm.

Differential Leukocytes

The relative differential leukocyte values are given in Table 6 for each age group and for all subjects. The mean value for all age groups is 37.4 ± 9.83 percent for lymphocytes, 4.1 ± 3.77 percent for monocytes, 55.7± 10.08 percent for neutrophils, 2.3 ± 2.25 percent for eosinophils, and 0.5 ± 0.63 percent for basophils.

The relative differential neutrophil values of 388 women are given in Table 7 for each age group and for all age groups. The mean value for all age groups is 48.9 ± 10.46 percent for segmented, 7.0 ± 4.73 percent for band, and 0.3 ± 1.24 for metamyelocytes.

Serum Protein

Serum protein values were determined for 517 subjects in 4 states. The mean and standard deviation are given in Table 8 for the women in each age group in each state, for all women in each age group, and for the 517 women studied.

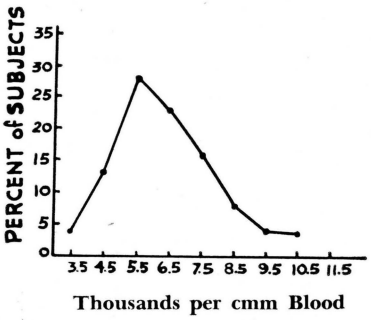

Figure 3. Distribution of total leukocyte values of 298 women.

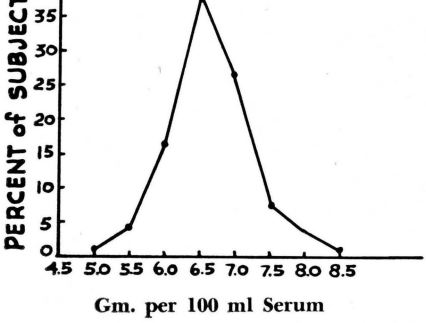

Figure 4. Distribution of serum protein values of 517 women.

Table 6. Relative differential leukocyte values in the blood of 598 women.[1]

Age group	Number of subjects	Lymphocytes		Monocytes		Total Neutrophils		Eosinophils		Basophils	
		Mean	S. D.[2]	Mean	S. D.	Mean	S. D.	Mean	S. D.	Mean	S. D.
years		%		%		%		%		%	
30-39	104	38.9	9.32	4.3	3.87	53.5	9.33	2.7	2.49	0.6	0.66
40-49	155	37.4	9.88	3.4	3.05	56.6	10.25	2.1	2.09	0.4	0.62
50-59	164	38.1	9.76	3.9	4.03	55.1	10.19	2.2	2.25	0.5	0.63
60-69	84	37.6	10.56	3.9	3.66	55.6	10.81	2.2	2.49	0.6	0.64
70-79	61	34.8	9.73	5.0	4.05	57.1	10.33	2.3	2.15	0.5	0.56
80-97	30	32.5	7.96	5.9	4.25	58.7	6.93	2.2	1.40	0.8	0.57
All subjects	598	37.4	9.83	4.1	3.77	55.7	10.08	2.3	2.25	0.5	0.63

[1] In Iowa, Michigan, Minnesota, Nebraska, and South Dakota.
[2] Standard Deviation

Table 7. Relative differential neutrophil values in the blood of 388 women.[1]

Age group	Number of subjects	Neutrophils							
		Total		Segmented		Band		Metamyelocytes	
		Mean	S. D.[2]	Mean	S. D.	Mean	S. D.	Mean	S. D.
years		%		%		%		%	
30-39	67	53.9	9.33	46.0	8.93	7.7	5.29	0.3	1.00
40-49	109	56.7	10.85	49.8	11.14	6.6	4.22	0.3	1.09
50-59	117	56.2	10.85	48.5	10.17	7.5	4.70	0.2	0.81
60-69	55	56.5	11.12	49.1	10.95	7.1	4.68	0.3	0.96
70-79	31	58.4	9.20	52.3	10.91	5.2	4.21	0.9	2.62
80-92	9	58.5	4.67	51.8	8.04	5.1	7.01	1.7	2.13
All subjects	388	56.2	10.43	48.9	10.46	7.0	4.73	0.3	1.24

[1] In Nebraska and South Dakota.
[2] Standard Deviation.

The range in values was from 5.3 to 8.7 grams per 100 milliliters of blood serum and the mean was 6.71 ± 0.61 gm. The distribution curve of the cases is shown in Figure 4. Sixty-five percent of the subjects had values between 6.0 and 7.5 gm per 100 ml.

The mean values for serum protein were similar for the subjects in each age group.

Calcium and Phosphorus

The calcium and inorganic phosphorus content of the blood serum of 281 women studied in Nebraska is shown for each age group and for all ages in Table 9.

Values for calcium ranged from 6.5 to 14.9 mg per 100 ml with a mean of 10.9 ± 1.73 mg. The distribution of cases is shown in Figure 5. Sixty percent of the cases were between 9.5 and 11.5 mg per 100 ml, and 84 percent were between 8.5 and 12.5 mg per 100 ml. There was no significant difference among the mean values for the different age decades from 30 to 80.

Table 8. Mean serum protein values of women of different ages and living in 5 North Central States.

Age group	Illinois	Iowa	Michigan	Nebraska	South Dakota	All states
30-39 years						
No. subjects	30	12	.....	61	9	112
Mean gm/100 ml	7.1	6.4	.....	6.7	6.0	6.7
S. D.[1]	0.86	0.39	.....	0.48	0.39	0.66
40-49 years						
No. subjects	24	16	.....	97	8	145
Mean gm/100 ml	7.1	6.5	.....	6.7	5.9	6.7
S. D.	0.65	0.24	.....	0.43	0.08	0.52
50-59 years						
No. subjects	12	14	.....	98	12	136
Mean gm/100 ml	7.4	6.5	.....	6.8	6.0	6.8
S. D.	0.77	0.49	.....	0.55	0.34	0.63
60-69 years						
No. subjects	20	8	.....	43	7	78
Mean gm/100 ml	7.0	6.7	.....	6.7	6.0	6.7
S. D.	0.67	0.45	.....	0.41	0.58	0.55
70-79 years						
No. subjects	5	8	.....	13	11	37
Mean gm/100 ml	7.4	6.5	.....	6.8	6.0	6.6
S. D.	1.46	0.28	.....	0.38	0.55	0.77
80-92 years						
No. subjects	3	1	.....	.....	5	9
Mean gm/100 ml	6.9	7.2	.....	.....	6.0	6.4
S. D.	0.86	.....	.....	.....	0.29	0.69
All ages						
No. subjects	94	59	.....	312	52	517
Mean gm/100 ml	7.1	6.6	.....	6.7	6.0	6.7
S. D.	0.88	0.37	.....	0.45	0.37	0.61

[1] Standard Deviation

Table 9. Calcium and inorganic phosphorus content of the blood serum of 281 women.[1]

Age group	Number of subjects	Calcium		Phosphorus	
		Mean	S. D.[2]	Mean	S. D.
years		mg/100 ml		mg/100 ml	
30-39	42	10.8	1.53	3.8	0.53
40-49	90	10.7	1.85	3.4	0.49
50-59	95	11.0	1.71	3.8	0.49
60-69	42	11.0	1.78	3.7	0.35
70-79	12	10.6	1.80	3.5	0.45
All subjects	281	10.9	1.73	3.7	0.50

[1] In Nebraska.
[2] Standard Deviation.

The inorganic phosphorus content of serum for women in all decades studied ranged from 2.4 to 5.1 mg phosphorus per 100 ml with a mean of 3.7 ± 0.50 mg per 100 ml. Figure 6 shows that 85 percent of the subjects had values between 3.2 and 4.2 mg per 100 ml. The mean for the women in the 40 to 49 year age group was significantly lower than the mean for the 30-39 year group (F = 3.78) and for the 50 to 59 year group (F = 5.14).

Glucose

Glucose tolerance was determined for 239 of the women studied in Nebraska. The values for the glucose content of the fasting blood, in the morning before the women had any food, and before they were given the dose of glucose, are presented in Table 10 for each age group and for all ages. The means for the different ages ranged from 98 to 101 mg per 100 ml. There was no significant difference between age groups. The average for all subjects was 98 ± 16 mg per 100 ml. The frequency distribution is shown in Figure 7.

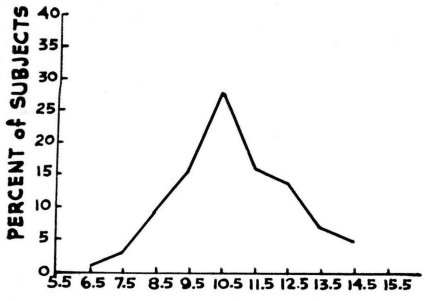

Figure 5. Distribution of serum calcium values of 281 women.

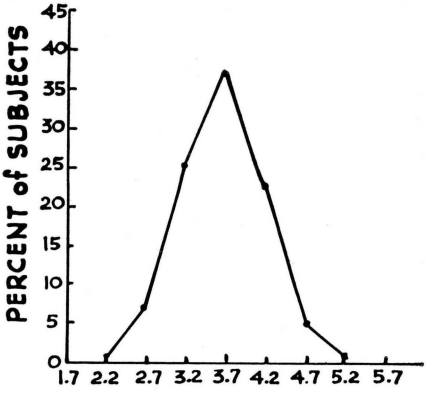

Figure 6. *Distribution of serum phosphorus values of 281 women.*

Table 10. Glucose in fasting blood of 239 women.[1]

Age group	Number of subjects	Glucose in fasting blood	
		Mean	S. D.[2]
years		mg per 100 ml	
30-39	39	99	18
40-49	69	98	16
50-59	82	98	15
60-69	40	101	16
70 and over	9	101	18
All subjects	239	98	16

[1] In Nebraska.
[2] Standard Deviation.

The responses of these women to the oral ingestion of 100 gm glucose were classified on the basis of the blood level of glucose prior to and two hours after the dose. The criteria for the sorting are described in the first column of Table 11 and in general are those of Moyer and Womack (24). The mean values for each time period are given in Table 11 and charted in Figure 8.

Moyer and Womack consider that fasting blood sugar values above 120 mg per 100 ml and values above 140 mg 2 hours after ingestion of glucose "should be taken to be diabetic," and that 2-hour values between 125 and 140 mg per 100 ml are "presumptively diabetic until proven otherwise."

There were 41 subjects who had 2-hour blood values above 140 mg glucose per 100 ml blood. Of these, however, only 7 had fasting values above 120 mg and they were the only women in whom the condition of diabetes was confirmed by subsequent tests by their physicians. No cases were considered severe. Four of the women were over 60 years of age.

Table 11. Response of 239 women to the glucose tolerance test.[1]

Criteria for grouping		Subjects		Glucose—mg per 100 ml (mg %)							
						After oral dose of 100 gm glucose					
Fasting mg %	2 hour mg %	No.	%	Fasting		½ hr.		1 hr.		2 hr.	
				Mean	SD[2]	Mean	SD	Mean	SD	Mean	SD
Normal Below 120	Normal Below 125	155	65	94	14	135	32	124	37	98	18
Normal Below 120	Borderline Between 125-140	31	13	102	12	151	12	152	32	132	4
Normal Below 120	High Above 140	34	14	103	13	161	35	175	34	170	31
High Above 120	Below 140	12	5	126	4	185	43	169	46	124	10
High Above 120	High Above 140	7	3	129	4	207	51	227	37	206	47

[1] In Nebraska.
[2] Standard Deviation.

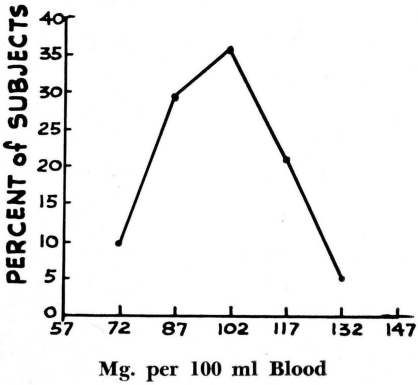

Figure 7. Distribution of fasting glucose values of 239 women.

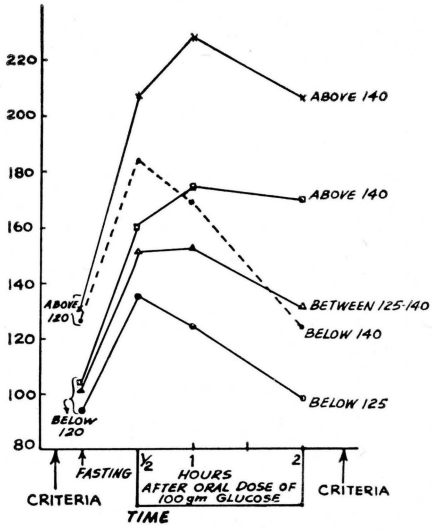

Figure 8. Mean glucose tolerance curves of 239 women.

Of the 155 women who had normal fasting and 2-hour values, the response of 66 could be described as a "flat curve" by the criteria of Mosenthal (23) and Hofstatter (16). The criteria include a fasting value of less than 120 mg per 100 ml, a maximum rise of less than 40 mg from the fasting value, and a drop at the end of the first or second hour to no lower than 75 mg. The mean values for these subjects are shown in Table 12. Fifteen of these subjects were in the 30 to 39 year age group, 22 were in the 40 to 49 year group, 23 in the 50 to 59 year group, and 6 were over 60 years of age.

DISCUSSION

The chief purpose of measuring the constituents of blood reported in this bulletin was to contribute information on blood values in

Table 12. Blood glucose values of 66 women with a flat glucose tolerance curve.[1]

Time	Glucose—mg per 100 ml	
	Mean	S. D.[2]
Fasting	96	16
After oral dose of 100 gm glucose:		
½ hour	115	25
1 hour	109	22
2 hour	99	22
3 hour[3]	87	21

[1] A sub-group of the 155 subjects shown in Table 10 with fasting values below 120 mg and 2 hour values below 125 mg per 100 ml.
[2] Standard Deviation.
[3] Only 46 of the 66 women had values determined at the end of the 3rd hour.

"healthy" or "normal" women. Discussion will be limited, therefore, to comparison of the results obtained with recent reports in the literature and with values considered to be "normal" or "standard" and in general use in hematology. Such values have been selected from two sources for comparison with the results secured in this study; one source was "Textbook of Medicine" by Cecil and Loeb (5) and the other "Standard Values in Blood" edited by Albritton (1). Of the studies selected from the literature, one reported by Gillum and her associates (10,11,22) from California is the most comparable to this one which was made in the North Central states. Both studies were phases of regional cooperative studies of nutritional status and similar in scope, purpose, and methodology.

Wherever possible the 95 percent range is given which omits the lowest and highest 2.5 percent of the values, assuming a normal distribution. This is calculated as the mean plus or minus two standard deviations.

Values for hemoglobin and red cell counts are listed in Tables 13 and 14, respectively. The mean of 13.4 gm hemoglobin per 100 ml blood reported by Gillum and Morgan (10) for women 50 to 80 years of age and over is closest to the mean of 13.3 gm secured in the present study. Their full range of 8.4 to 20.0 gm per 100 ml blood, however, is greater than the 9.5 to 17.0 gm found in the present study. When Hawkins et al (13) reported results of their study in Halifax, they included a summary of the hemoglobin values which have been reported, mostly within the last 10 years, particularly from Canada, the United States and Great Britain. In the summary the means for women in different age groups from 17 to 86 years ranged from 12.5 to 13.8 gm hemoglobin per 100 ml blood.

Judy and Price (18) recently have reviewed and evaluated standards for hemoglobin and red cell counts and presented results secured on 663 healthy women. Their results, which show no difference in values for different age groups, are significantly lower than the standards

Table 13. Hemoglobin values for women reported in the recent literature.

Source	No. subjects	Age	Hemoglobin	
			Mean	95% Range
		years	gm per 100 ml blood	
This study	698	30-92	13.3	11.4 - 15.2
Gillum and Morgan (10)	296	50-80 and over	13.4	8.4 - 20.0 (full range)
Judy and Price (18)	663	11-69	12.55	10.2 - 14.8
Hawkins et al (13)	326	21-94	13.0	10.4 - 15.6
Mirone (21)	396	27[1]	13.99	10.39 - 16.83
Albritton (1)	"standard"		13.9	11.5 - 16.0
Cecil and Loeb (5)	"normal"		.....	12.8 - 15.2

[1] Average age of group.

Table 14. Red cell counts for women reported in the recent literature.

Source	No. subjects	Age	Red blood cells	
			Mean	95% Range
			millions per cmm blood	
This study	608	30-92	4.68	3.74 - 5.62
Judy and Price (18)	663	11-69	4.37	3.81 - 5.03
Albritton (1)	"standard"		4.8	4.2 - 5.4
Cecil and Loeb (5)	"normal"			4.2 - 5.5

quoted as normal by hematologists and textbooks. They stress the need for standards based on an adequate sampling of normal subjects and point out the futility in medical practice of striving for blood values higher than normal or average.

The averages of 12.55 ± 1.15 gm hemoglobin per 100 ml and 4.37 ± 0.282 million red cells per cmm that are suggested as reference figures by Judy and Price are somewhat lower than the 13.3 ± 0.95 and 4.68 ± 0.47 reported in the present study. The criteria used by Judy and Price for normal women, however, included more detailed medical histories and clinical evaluations than those used in choosing subjects for this present study of nutritional status.

Additional evidence of the lack of change in hemoglobin concentration and red cell count from early to late adulthood is found in the comparison of the values for the women 30 to 92 years of age in 6 North Central States with those of college women 16 to 30 years of age in the same region reported by Ohlson et al (26):

Hemoglobin—gm per 100 ml	
698 women in this study	13.3 ± 0.95
4550 college women	13.4 ± 1.16
Red blood cells—m per cmm	
608 women in this study	4.68 ± 0.47
1792 college women	4.56 ± 0.38

Leukocytes

The total and differential leukocyte values obtained in this study are compared in Table 15 with those given in Albritton (1) and in the medical textbook by Cecil and Loeb (5). The mean values for the differential values found for the women in this study were near the values given by Albritton and within the ranges given by Cecil and Loeb (5) but the range in values was somewhat greater.

Serum Protein

The values for serum protein are compared in Table 16. Those found in this study and the similar study of Morgan et al (22) in California are at the lower edge of the range of normal values given in Albritton (1) and in Cecil and Loeb (5) and definitely lower than the values reported by Josephson and Dahlberg (17).

Table 15. Comparison of total and differential leukocyte values of women.

	This study		Albritton (1)	Cecil and Loeb (5)
	Mean	S.D.[1]		
Total leukocytes thousands per cmm	6.4 ±	1.6[1]	7.4 4.5-11.0	5-10
Differential %				
Neutrophils	55.7 ±	10.1	59	50-65
Lymphocytes	37.4 ±	9.8	34	25-35
Monocytes	4.1 ±	3.8	4.0	4-10
Eosinophils	2.3 ±	2.3	2.7	0.5-4
Basophils	0.5 ±	0.6	0.5	0-2

[1] Standard Deviation.

Table 16. Comparison of blood values for serum protein of women.

Source	No. women	Age	Serum protein	
			Mean	95% Range
		years		gm per 100 ml
This study	517	30-92	6.7	5.5 - 7.9
Morgan et al (22)	294	50-80+	6.44	5.2 - 7.7 (full range)
Josephson and	141	Under 50	7.96	6.88 - 9.04
Dahlberg (17)	54	Over 70	7.90	6.98 - 8.82
Albritton (1)	"standard"		7.2	6.5 - 7.9
Cecil and Loeb (5)	"normal"		.....	6.5 - 8.0

Calcium and Phosphorus

Figures in Table 17 indicate that the mean serum calcium and phosphorus values for 281 women in this study are similar to those reported by Josephson and Dahlberg (17) for women under 50 years and over 70 years of age. The ranges for both calcium and phosphorus are somewhat greater than in the standards listed. Josephson and Dahlberg found that age had no appreciable effect on the calcium values of the serum but that there was a significant lowering in the serum phosphorus values with advancing age and a reduction in variability. Such a lowering was not apparent in the values for the women in this study.

Table 17. Comparison of calcium and phosphorus values in serum of women.

Source	No. women	Age	Calcium		Phosphorus	
			Mean	95% Range	Mean	95% Range
		years		mg per 100 ml		
This study	281	30-79	10.9	7.4-14.4	3.7	2.7-4.7
Josephson and	141	Under 50	11.0	9.4-12.5	3.6	2.2-5.1
Dahlberg (17)	54	Over 70	11.2	9.4-12.8	3.0	2.1-3.9
Albritton (1)	"standard"		10.4	8-11	2.9	2.1-3.8
Cecil and Loeb (5)	"normal"			9-11	..	3.0-4.5

Glucose

The test of glucose tolerance revealed seven cases of diabetes (none considered severe by the physicians) which had not been detected previously. The prevalence of 3 percent in this group of 239 "healthy" women 30 years of age and older probably is not out of line with the figure of 1.7 percent given in the U. S. Public Health Service Reports (33) for the entire population of the USA.

The incidence of a flat glucose tolerance curve was also higher than expected—28 percent among the women studied as compared with 7 percent reported by Marshall (20) among elderly men, and 10 percent reported by Hofstatter (16) among elderly men and women. Mosenthal (23) considered that the flat curve indicated an increased sugar tolerance and that it was not commonly encountered among normal individuals. Marshall, however, has attributed a flat curve to a deficient absorption of glucose which in turn might be due to a diminished motility of the stomach, atrophy of the intestinal mucosa, or destruction of large amounts of glucose by intestinal bacteria.

Gillum et al (11) determined the glucose content of the blood two hours after a carbohydrate meal in 229 "supposedly healthy" women over 50 years of age. The mean value for 219 of the women with values below 130 mg per 100 ml was 100.9 mg (Range 60-129), with a standard error of 3.8. Ten women had values above 130 mg.

Nutrient Intake

No significant correlations were found between the amount of protein in the diets of the women and the hemoglobin levels, or between the intake of other nutrients and the level of other blood constituents measured. In general, the women had intakes of nutrients that exceeded two-thirds of the National Academy of Sciences—National Research Council recommended allowances. The nutrients most likely to be in short supply in their self-chosen diets were calcium, thiamine, and riboflavin. The lack of correlation between dietary intake and blood values is not surprising since the women were chosen to be subjects on the basis of being in good health.

SUMMARY

The hemoglobin, red cell, total and differential leukocyte, serum protein, calcium, phosphorus and glucose values of the blood of several hundred healthy women 30 to 92 years in 6 North Central States were determined as one phase of a regional study of nutritional status. The mean, standard deviation and the 95 percent range (mean plus or minus two standard deviations), are shown in Table 18 for each constituent measured.

The values for these healthy women tend to be slightly lower than values given as standards in textbooks. Differences between age groups were not significant.

Table 18. Summary of means, standard deviation, and 95 percent range for blood values of women in 6 North Central States.

Constituent	Mean	Standard deviation	95% Range
Hemoglobin—gm per 100 ml	13.3	0.95	11.4 - 15.2
Red Cells—million per cmm	4.68	0.47	3.74 - 5.62
Leukocytes—thousands per cmm	6.40	1.64	3.12 - 9.68
Differential—percent			
Neutrophils—total	55.7	10.08	.....
Segmented	48.9	10.46	.....
Band	7.0	4.73	.....
Metamyelocytes	.3	1.24	.....
Lymphocytes	37.4	9.83	.....
Monocytes	4.1	3.77	.....
Eosinophils	2.3	2.25	.....
Basophils	0.5	0.63	.....
Serum protein—gm per 100 ml	6.7	0.61	3.12 - 9.68
Calcium—mg per 100 ml	10.9	1.73	7.4 - 14.4
Phosphorus—mg per 100 ml	3.7	0.50	2.7 - 4.7
Glucose fasting—mg per 100 ml	98	16	66 - 130

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ACKNOWLEDGMENTS

The authors wish to express appreciation to the women who served as subjects and to acknowledge the assistance of the following staff members:

Illinois

Floyd Boys' College of Physical Education.
Theresa W. Loeffler
Beula McKey
Winifred Newton

Iowa

Norma Howard
Jane Smith Stiles
Margaret Codlin Johnson
Pilar Garcia
Charlotte Roderuck

Michigan

Dena Cederquist
Lois Jackson Campbell
Louise Kelley

Nebraska

Marcella Carter (Bureau of Human Nutrition and Home Economics, U.S.D.A. field staff)
Mary Rose Gram
Marilyn Chaloupka Kirk
Marguerite Muir
Eileen Brodovsky
Norma Spomer Johnson
Amy Mitchell
Mary Gibb