NUTRITIONAL STATUS OF SELECTED POPULATION GROUPS IN OREGON

II. BIOCHEMICAL TESTS ON THE BLOOD OF NATIVE BORN AND REARED SCHOOL CHILDREN IN TWO REGIONS[1]

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THIS paper is a report of the biochemical tests on the blood of selected population groups in the Coast and Central Regions, and presents the results of one of the phases of the Western Regional Research project on nutritional status of selected population groups in Oregon. The general plan of the entire project may be found in Part I (1) of this series of papers.

MATERIAL AND METHODS

The basis for the selection of the children examined has been described in Part I (1).

Five chemists, two in the field and three in the research laboratory at Oregon State College, devoted full-time to the analytical work in this study. Each chemist assumed full responsibility for one or more of the biochemical tests on the blood, *e.g.*, one chemist made all of the serum ascorbic acid analyses and another analyzed all of the serum samples for carotene and vitamin A.

Samples of blood from 766 non-fasting subjects were obtained by finger-puncture with a Bard-Parker blade. In order

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to facilitate the work of the chemists, ten children reported at 9: 00 A.M., six at 10: 30 A.M. and the remaining eight at 1: 00 P.M. Such a schedule made it possible for the hemoglobin, hematocrit, and plasma protein determinations to be made on the samples from one group of children before the next group appeared. The other blood samples which were collected in 3 mm × 100 mm capillary tubes were sealed with Pyseal, centrifuged, packed in a Dewar flask containing dry ice and sent to the Nutrition Research Laboratory at Oregon State College where the following analyses were made on the serum: vitamin A, carotene, and ascorbic acid.

Analytical Procedures

Serum Vitamin A and Carotene. Vitamin A and carotene were determined on 85 mm^3 aliquots of serum according to the method of Bessey, Lowry, Brock, and Lopez (2). That "method depends on (1) saponification and extraction of the vitamin A and carotene from serum on a micro scale with solvents of low volatility; (2) measurement of the light absorption of small volumes at 328 and 460 mμ; (3) destruction of the vitamin A absorption at 328 mμ without affecting the absorption of other compounds at this wave length; and (4) remeasurement of the absorption at 328 mμ." Microgram per cent carotene = $(E_{460})(480)$. Microgram per cent vitamin A = (E_{328} before irradiation—E_{328} after irradiation)(637).

Serum Ascorbic Acid. The total ascorbic acid content was determined on 10 mm^3 aliquots of serum according to the Bessey, Lowry, and Brock (3) modification of the method of Lowry, Lopez, and Bessey (4) in which dinitrophenylhydrazine, which measures ascorbic acid after oxidation to dehydroascorbic acid, was used.

Hemoglobin. Hemoglobin was determined colorimetrically as alkaline hematin (Lowry) (5) with a Leitz Photoelectric Colorimeter which had been calibrated against the oxygen capacity method of Van Slyke and the alkaline hematin solutions read on the Beckman Spectrophotometer.

Hematocrit Value. The blood for hematocrit value determinations (Lowry) (5) was collected in 2 mm × 100 mm capillary tubes. A few crystals of Heparin sodium[3] in the tips of the tubes served as the anticoagulant. The ends of the tubes were sealed with Pyseal. The tubes were centrifuged at full speed in a clinical centrifuge for one hour. The length of the column of blood cells plus plasma as well as the length of the column of blood cells were recorded. Hematocrit values, *i.e.*, per cent of red blood cells was calculated as follows:

$$\frac{\text{Length of column of red blood cells}}{\text{Length of column of red blood cells + plasma}} (100) = \text{Hematocrit value.}$$

Plasma Protein. The plasma which was obtained in the estimation of hematocrit value was used for the determination of plasma protein. The Lowry and Hunter (6) gradient tube method for the determination of specific gravity was used. A linear density gradient was prepared in a graduated cylinder with mixtures of different proportions of kerosene and bromobenzene. Using potassium sulfate, six specific gravity standards, 1.0141, 1.0184, 1.0227, 1.0270, 1.0313, 1.0356, were prepared which correspond to plasma protein concentrations of 2.5, 4.0, 5.5, 7.0, 8.5 and 10 per cent, respectively. The protein concentration was read from a curve based on the position of the droplets of the standard specific gravity solutions.

Results and Discussion

Table 1 shows the number of biochemical tests performed in each of the four counties in Oregon, together with the mean values and ranges for each test according to the age and sex of the children studied. Not all determinations were available for all the children examined. The greatest number of determinations was made for hemoglobin (766) of which 425 were taken in the Coast Region consisting of Clatsop and Coos Counties and 341 in the Central Region which covered Desch-

[3] Obtained through the courtesy of Roche-Organon, Nutley, New Jersey.

County	Age	Sex	(1) Vitamin A			(2) Carotene			(3) Ascorbi	
			No. Cases	Mean Mcg Per Cent	Range Mcg Per Cent	No. Cases	Mean Mcg Per Cent	Range Mcg Per Cent	No. Cases	M
Clatsop	14	F	28	24	1–55	35	105	23–262	35	
	14	M	30	30	12–84	36	107	48–219	37	
	15	F	23	33	15–89	27	107	46–214	29	
	15	M	21	27	8–93	21	100	40–193	23	
	16	F	18	27	9–49	20	111	57–177	20	
	16	M	28	37	20–94	30	100	38–207	32	
Coos	14	F	46	32	6–68	46	109	55–205	47	
	14	M	48	31	8–56	48	103	35–194	48	
	15	F	33	32	10–52	33	114	40–189	34	
	15	M	55	32	10–64	55	99	48–159	55	
	16	F	33	38	13–61	33	126	75–214	33	
	16	M	28	41	10–70	28	103	38–192	28	
Deschutes	14	F	24	28	10–44	25	111	73–173	25	
	14	M	11	34	21–53	11	135	84–187	11	
	15	F	24	30	10–52	25	109	39–251	25	
	15	M	10	39	25–68	10	109	55–155	10	
	16	F	24	35	7–54	24	107	58–208	24	
	16	M	16	37	19–56	16	108	65–174	16	
Klamath	14	F	43	33	15–51	43	103	26–210	43	
	14	M	37	35	18–63	39	102	38–195	40	
	15	F	42	35	13–54	44	104	36–245	44	
	15	M	36	37	10–61	37	96	50–277	38	
	16	F	35	31	10–45	35	90	50–156	35	
	16	M	30	45	25–61	30	107	49–212	30	

Table 1. Results of biochemical tests on the blood, blood plasma and blood serum of 14, 15, and 16 year old children in four counties in Oregon.

utes and Klamath Counties. Fewest results were for vitamin A, 391 in the Coast Region and 332 in the Central Region, making a total of 723 determinations. The means should be considered in connection with the range of values as shown in the table, because the distributions covered wide ranges and were skewed in some groups.

In Table 2, mean values for blood constituents and the significance of differences between counties within regions, and between regions are presented. Several differences are highly significant statistically, especially in the Central Region, as indicated by the double asterisks in the table. However, as will

(4) Hemoglobin			(5) Hematocrit			(6) Plasma Protein		
No. Cases	Mean Gm Per Cent	Range Gm Per Cent	No. Cases	Mean	Range	No. Cases	Mean Gm Per Cent	Range Gm Per Cent
35	13.7	11.6–15.1	32	41	33–57	32	7.0	6.0–8.0
37	14.4	12.1–16.1	35	42	32–54	35	7.1	6.0–7.7
30	13.7	11.7–15.0	29	41	30–48	30	7.2	6.4–7.9
23	14.6	13.1–16.4	20	44	38–49	21	7.0	6.1–7.5
21	13.5	11.4–15.1	20	40	34–47	21	7.1	6.1–7.9
32	15.0	13.2–16.9	31	45	39–58	31	7.2	6.4–8.5
48	13.0	10.2–14.9	45	40	34–47	47	7.0	6.4–8.5
48	13.9	11.9–16.0	44	42	37–49	44	6.9	6.3–7.7
34	13.2	11.4–14.8	32	41	34–50	33	7.0	5.5–8.1
56	14.5	11.8–16.8	53	44	32–50	52	7.0	5.8–8.0
33	13.5	11.8–15.0	33	41	33–47	33	7.1	6.4–8.0
28	14.5	11.9–17.6	24	45	36–53	26	7.1	6.5–8.0
25	13.5	8.2–14.7	24	41	30–47	25	6.9	6.0–7.3
11	14.7	13.0–16.1	11	45	37–53	11	6.9	6.1–7.5
25	13.7	11.9–15.8	23	42	37–48	25	7.2	6.7–8.2
10	15.3	14.5–16.5	9	47	43–54	9	6.9	6.1–7.3
24	13.7	12.4–14.9	24	41	37–49	24	7.2	6.7–7.9
16	15.2	13.7–17.8	16	46	39–51	16	7.2	6.7–8.2
43	14.0	10.5–15.5	40	44	33–49	42	7.0	6.2–7.7
40	14.6	12.7–16.8	40	45	38–53	40	6.8	5.9–7.7
44	14.1	12.7–15.6	44	43	33–51	44	7.1	6.4–7.9
38	14.9	12.9–16.9	37	45	26–55	37	6.9	6.1–8.3
35	14.0	12.7–16.0	34	43	39–49	35	7.0	6.3–7.9
30	15.9	13.5–19.6	29	49	43–56	29	7.0	6.2–7.6

be clarified in the following paragraphs, in a practical sense these differences are of little importance since they fall within the limits of specified levels of nutrition.

The biochemical data classified by the levels of blood constituents proposed by Bessey and Lowry (7), have been presented in Table 3 by counties, in Table 4 for boys and girls separately by region, and in Table 5 for boys and girls separately by age groups.

Serum vitamin A levels were highest in Klamath County of the Central Region and lowest in Clatsop County of the Coast Region (Table 3). Children in Coos County rated about equal to those in Deschutes County. Serum carotene values were lowest in Klamath County; highest in Coos County. Serum

ascorbic acid values were highest in Deschutes County, and lowest in Klamath County, both of the Central Region. Hemoglobin and hematocrit values were highest in Klamath and Deschutes Counties, both in the Central Region, and lowest in Coos County. In plasma protein, all counties ranked too high on the standards used to show county differences.

When the results were classified by sex in each region (Table 4), girls were higher in some biochemical tests, the boys higher in others. For serum vitamin A boys rated higher than girls in each region, but for serum carotene the girls rated about as good or better than the boys. For serum ascorbic acid values the girls far outranked the boys in each region, and the difference was highly significant statistically. For hemoglobin the boys of both regions rated slightly higher at the highest level. Hematocrit values were also higher among the boys in both

Table 2. Mean values for blood constituents and their statistical significance[1] for children studied in Oregon by region and county.

	Blood Constituent					
	Serum Vitamin A Mcg/100 Ml	Serum Carotene Mcg/100 Ml	Serum Ascorbic Acid Mcg/100 Ml	Hemoglobin Gm/100 Ml	Hematocrit Per Cent	Plasma Protein Gm/100 Ml
Coast Region						
Clatsop County	30	101	0.81	14.31	42	7.0
Coos County	34	110	0.88	13.78	42	7.0
Significance of Difference	*	—	—	**	—	—
Central Region						
Deschutes County	34	114	0.98	14.10	43	7.1
Klamath County	36	101	0.77	14.56	45	7.0
Significance of Difference	—	**	**	**	**	*
Region						
Coast	33	108	0.86	13.94	42	7.0
Central	35	105	0.83	14.41	44	7.0
Significance of Difference	*	—	—	**	**	—

* Significant at 5 per cent level.
** Significant at 1 per cent level.

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regions. Plasma protein values showed no appreciable difference between the sexes.

When the biochemical data were classified by age groups of boys and girls in the four counties combined (Table 5), there was some relationship to age in most of the tests made. Serum vitamin A levels increased with age, but trends in serum carotene were less consistent. Serum ascorbic acid values tended to increase with age of girls, but trends were less consistent for boys. Both hemoglobin and hematocrit values were higher in older children. For hemoglobin, the increase in values with age was highly significant. For plasma protein, distributions were skewed but there appeared to be no relationship to age.

In order to determine possible relationship between pairs of biochemical tests, correlation coefficients were calculated and are presented in Table 6. Highly significant positive correlations were obtained for the following pairs of tests: serum vitamin A and serum carotene, serum vitamin A and serum ascorbic acid, serum vitamin A and hemoglobin, serum vitamin A and hematocrit value, serum carotene and serum ascorbic acid, and hemoglobin and hematocrit value.

Comments

Of the surveys on children which have been made, the one by Bessey and Lowry (7) on 1,200 New York State school children is most nearly comparable to the one reported in this paper. The results of the serum vitamin A determinations in the above-mentioned study in New York revealed that about 80 per cent of the children had values classified as "good." In the Oregon study, 54.1 per cent of the children had serum vitamin A values in that classification. Of the children of schools A, B, and C in the New York study about 50 per cent of them were classified as "fair" with respect to serum carotene. Likewise, in the Oregon study 50.5 per cent of the children were classified as "fair." The children in the New York study showed considerable variation in the concentration of ascorbic acid in the serum. Whereas, there were more Oregon children classified in the "excellent" group than in any of the other three groups, the

Blood Constituent	Level of Nutrition[1] Unit 100 Ml.	Clatsop County No. of Cases	Clatsop County Per Cent	Coos County No. of Cases	Coos County Per Cent
Serum Vitamin A Mcg./100 Ml.	Poor (Below 20)	11	8.9	38	15
	Fair (20–29)	33	27.2	47	19
	Good (30–45)	44	32.4	139	57
	Excellent (50 and Over)	24	9.5	19	7
Total		144	100.0	243	100
Serum Carotene Mcg./100 Ml.	Poor (Below 75)	38	22.5	47	19
	Fair (75–124)	96	53.9	122	50
	Good (125–199)	42	24.3	71	29
	Excellent (200 and Over)	4	2.4	3	1
Total		165	100.1	243	99
Serum Ascorbic Acid Mg./100 Ml.	Poor (Below 0.4)	31	17.6	37	15
	Fair (0.4–0.7)	40	22.7	64	26
	Good (0.8–1.2)	42	23.6	64	26
	Excellent (1.3 and Over)	64	36.4	80	33
Total		177	100.0	245	100
Hemoglobin Gm./100 Ml.	Poor[2]	1	0.0	4	2
	Fair[3]	27	15.2	79	32
	Good[4]	82	46.1	102	41
	Excellent[5]	68	38.8	62	25
Total		178	100.1	247	100
Hematocrit Value Per Cent	Poor (Below 35)	4	2.4	1	0
	Fair (35–39)	33	19.8	51	22
	Satisfactory (40 and Over)	130	77.8	179	78
Total		167	100.0	231	100
Plasma Protein Gm./100 Ml	Poor (Below 6.0)	1	0.6	2	1
	Fair (6.0–6.4)	8	4.7	10	4
	Satisfactory (6.5 and Over)	161	94.7	223	95
Total		170	100.0	235	100

Table 1. Number and per cent of children in selected areas of Oregon ha[ving] levels of nutrition indicated by biochemical tests on blood.

[1] Based on ratings of Bessey and Lowry (7). [2] Since hemoglobin values vary with age and sex the following ratings w[ere] used:

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Deschutes County		Klamath County		Central Region		All Four Counties	
of es	Per Cent	No. of Cases	Per Cent	No. of Cases	Per Cent	No. of Cases	Per Cent
3	11.9	14	6.3	27	8.1	96	13.3
)	27.5	40	17.9	70	21.1	172	23.8
	50.5	149	66.8	204	61.4	391	54.1
	10.1	20	9.0	31	9.3	64	8.9
	100.0	223	100.0	332	99.9	723	100.0
	18.0	61	26.8	81	23.9	166	22.1
	52.3	113	49.6	171	50.4	379	50.5
	27.9	49	21.5	80	23.6	192	25.6
	1.8	5	2.2	7	2.1	14	1.9
	100.0	228	100.1	339	100.0	751	100.1
	12.6	61	26.5	75	22.0	143	18.8
	18.9	43	18.7	64	18.8	168	22.0
	22.5	56	24.3	81	23.8	186	24.4
	45.9	70	30.4	121	35.5	265	34.8
	99.9	230	100.0	341	100.1	762	100.0
	0.9	1	0.4	2	0.6	6	0.8
	12.6	17	7.4	31	9.1	137	17.9
	45.9	80	34.8	131	38.4	315	41.1
	40.5	132	57.4	177	51.9	308	40.2
	99.9	230	100.0	341	100.0	766	100.0
	0.9	1	0.4	2	0.6	7	1.0
	16.8	12	5.4	30	9.1	114	15.6
	82.2	211	94.2	299	90.3	608	83.4
	99.9	224	100.0	331	100.0	729	100.0
	0.0	1	0.4	1	0.3	4	0.5
	6.4	7	3.1	14	4.2	32	4.3
	93.6	219	96.5	322	95.5	706	95.1
	100.0	227	100.0	337	100.0	742	99.9

Girls	*14 yr. Boys*	*15–16 yr. Boys*
Below 11.0	Below 11.5	Below 12.0
11.0–12.9	11.5–13.4	12.0–13.9
13.0–13.9	13.5–14.4	14.0–14.9
14.0 and over	14.5 and over	15.0 and over

Blood Constituent	Level of Nutrition[1] Unit/100 Ml.	Clatsop County		Co Cou
		No. of Cases	Per Cent	No. of Cases
Serum Vitamin A Mcg./100 Ml.	Poor (Below 20)	31	20.9	38
	Fair (20–29)	55	37.2	47
	Good (30–49)	48	32.4	139
	Excellent (50 and Over)	14	9.5	19
Total		148	100.0	243
Serum Carotene Mcg./100 Ml.	Poor (Below 75)	38	22.5	47
	Fair (75–124)	86	50.9	122
	Good (125–199)	41	24.3	71
	Excellent (200 and Over)	4	2.4	3
Total		169	100.1	243
Serum Ascorbic Acid Mg./100 Ml.	Poor (Below 0.4)	31	17.6	37
	Fair (0.4–0.6)	40	22.7	64
	Good (0.7–1.0)	41	23.3	64
	Excellent (1.1 and Over)	64	36.4	80
Total		176	100.0	245
Hemoglobin Gm./100 Ml.	Poor[2]	0	0.0	4
	Fair[2]	27	15.2	79
	Good[2]	82	46.1	102
	Excellent[2]	69	38.8	62
Total		178	100.1	247
Hematocrit Value Per Cent	Poor (Below 33)	4	2.4	1
	Fair (33–39)	33	19.8	51
	Satisfactory (40 and Over)	130	77.8	179
Total		167	100.0	231
Plasma Protein Gm./100 Ml.	Poor (Below 6.0)	1	0.6	2
	Fair (6.0–6.4)	8	4.7	10
	Satisfactory (6.5 and Over)	161	94.7	223
Total		170	100.0	235

Table 3. Number and per cent of children in selected areas of Oregon having levels of nutrition indicated by biochemical tests on blood.

[1] Based on ratings of Bessey and Lowry (7).
[2] Since hemoglobin values vary with age and sex the following ratings were used:

(Continued on page 263)

	Deschutes County		Klamath County		Central Region		All Four Counties	
:r nt	No. of Cases	Per Cent	No. of Cases	Per Cent	No. of Cases	Per Cent	No. of Cases	Per Cent
.6	13	11.9	14	6.3	27	8.1	96	13.3
.1	30	27.5	40	17.9	70	21.1	172	23.8
.8	55	50.5	149	66.8	204	61.4	391	54.1
.4	11	10.1	20	9.0	31	9.3	64	8.9
.0	109	100.0	223	100.0	332	99.9	723	100.0
.6	20	18.0	61	26.8	81	23.9	166	22.1
.5	58	52.3	113	49.6	171	50.4	379	50.5
.2	31	27.9	49	21.5	80	23.6	192	25.6
.7	2	1.8	5	2.2	7	2.1	14	1.9
.0	111	100.0	228	100.1	339	100.0	751	100.1
.2	14	12.6	61	26.5	75	22.0	143	18.8
.7	21	18.9	43	18.7	64	18.8	168	22.0
.9	25	22.5	56	24.3	81	23.8	186	24.4
.2	51	45.9	70	30.4	121	35.5	265	34.8
.0	111	99.9	230	100.0	341	100.1	762	100.0
.9	1	0.9	1	0.4	2	0.6	6	0.8
.9	14	12.6	17	7.4	31	9.1	137	17.9
.3	51	45.9	80	34.8	131	38.4	315	41.1
.8	45	40.5	132	57.4	177	51.9	308	40.2
.9	111	99.9	230	100.0	341	100.0	766	100.0
.3	1	0.9	1	0.4	2	0.6	7	1.0
.1	18	16.8	12	5.4	30	9.1	114	15.6
.6	88	82.2	211	94.2	299	90.3	608	83.4
.0	107	99.9	224	100.0	331	100.0	729	100.0
.7	0	0.0	1	0.4	1	0.3	4	0.5
.4	7	6.4	7	3.1	14	4.2	32	4.3
.8	103	93.6	219	96.5	322	95.5	706	95.1
.9	110	100.0	227	100.0	337	100.0	742	99.9

	Girls	*14 yr. Boys*	*15–16 yr. Boys*
Poor	Below 11.0	Below 11.5	Below 12.0
Fair	11.0–12.9	11.5–13.4	12.0–13.9
Good	13.0–13.9	13.5–14.4	14.0–14.9
Excellent	14.0 and over	14.5 and over	15.0 and over

Blood Constituent	Level of Nutrition[1] Unit/100 Ml.	Coastal Region			
		Boys		Girls	
		No. of Cases	Per Cent	No. of Cases	Per Cent
Serum Vitamin A Mcg./100 Ml.	Poor (Below 20)	30	14.3	39	21.5
	Fair (20–29)	59	28.1	43	23.8
	Good (30–49)	102	48.6	85	47.0
	Excellent (50 and Over)	19	9.0	14	7.7
Total		210	100.0	181	100.0
Serum Carotene Mcg./100 Ml.	Poor (Below 75)	52	23.9	33	17.0
	Fair (75–124)	113	51.8	95	49.0
	Good (125–199)	51	23.4	61	31.4
	Excellent (200 and Over)	2	0.9	5	2.6
Total		218	100.0	194	100.0
Serum Ascorbic Acid Mg./100 Ml.	Poor (Below 0.4)	50	22.4	18	9.1
	Fair (0.4–0.6)	66	29.6	38	19.2
	Good (0.7–1.0)	45	20.2	60	30.3
	Excellent (1.1 and Over)	62	27.8	82	41.4
Total		223	100.0	198	100.0
Hemoglobin Gm./100 Ml.	Poor[2]	3	1.3	1	0.5
	Fair[2]	54	24.1	52	25.9
	Good[2]	89	39.7	95	47.3
	Excellent[2]	78	34.8	53	26.4
Total		224	99.9	201	100.1
Hematocrit Value Per Cent	Poor (Below 33)	3	1.4	2	1.0
	Fair (33–39)	20	9.7	64	33.5
	Satisfactory (40 and Over)	184	88.9	125	65.4
Total		207	100.0	191	99.9
Plasma Protein Gm./100 Ml.	Poor (Below 6.0)	1	0.5	2	1.0
	Fair (6.0–6.4)	7	3.3	11	5.6
	Satisfactory (6.5 and Over)	201	96.2	183	93.4
Total		209	100.0	196	100.0

Table 4. Number and per cent of boys and girls in two regions of Oregon having levels of nutrition indicated by biochemical tests on blood.

[1] Based on ratings of Bessey and Lowry (7).
[2] Since hemoglobin values vary with age and sex the following ratings were used:

(Continued on page 265)

Central Region			Both Regions			
	Girls		Boys		Girls	
Per Cent	No. of Cases	Per Cent	No. of Cases	Per Cent	No. of Cases	Per Cent
4.3	21	10.9	36	10.3	60	16.1
16.4	47	24.5	82	23.4	90	24.1
62.9	116	60.4	190	54.3	201	53.9
16.4	8	4.2	42	12.0	22	5.9
100.0	192	100.0	350	100.0	373	100.0
21.0	51	26.0	82	22.7	84	21.5
52.4	96	49.0	188	52.1	191	49.0
25.2	44	22.4	87	24.1	105	26.9
1.4	5	2.6	4	1.1	10	2.6
100.0	196	100.0	361	100.0	390	100.0
27.6	35	17.9	90	24.5	53	13.5
19.3	36	18.4	94	25.5	74	18.8
17.9	55	28.1	71	19.3	115	29.2
35.2	70	35.7	113	30.7	152	38.6
100.0	196	100.1	368	100.0	394	100.1
0.0	2	1.0	3	0.8	3	0.8
9.7	17	8.7	68	18.4	69	17.4
33.1	83	42.3	137	37.1	178	44.8
57.2	94	48.0	161	43.6	147	37.0
100.0	196	100.0	369	99.9	397	100.0
0.7	1	0.5	4	1.1	3	0.8
4.2	24	12.7	26	7.4	88	23.2
95.1	164	86.8	319	91.4	289	76.1
100.0	189	100.0	349	99.9	380	100.1
0.7	0	0.0	2	0.6	2	0.5
4.2	8	4.1	13	3.7	19	4.9
95.1	187	95.9	336	95.7	370	94.6
100.0	195	100.0	351	100.0	391	100.0

	Girls	*14 yr. Boys*	*15–16 yr. Boys*
Poor	Below 11.0	Below 11.5	Below 12.0
Fair	11.0–12.9	11.5–13.4	12.0–13.9
Good	13.0–13.9	13.5–14.4	14.0–14.9
Excellent	14.0 and over	14.5 and over	15.0 and over

Blood Constituent	Level of Nutrition[1] Unit/100 Ml.	14 Year Old Boys		14 Year Old Girls	
		No. of Cases	Per Cent	No. of Cases	Per Cent
Serum Vitamin A Mcg./100 Ml.	Poor (Below 20)	17	13.5	28	19.9
	Fair (20–29)	36	28.6	40	28.4
	Good (30–49)	65	51.6	67	47.5
	Excellent (50 and Over)	8	6.3	6	4.3
Total		126	100.0	141	100.1
Serum Carotene Mcg./100 Ml.	Poor (Below 75)	27	20.1	27	18.1
	Fair (75–124)	71	53.0	82	55.0
	Good (125–199)	35	26.1	36	24.2
	Excellent (200 and Over)	1	0.7	4	2.7
Total		134	99.9	149	100.0
Serum Ascorbic Acid Mg./100 Ml.	Poor (Below 0.4)	33	24.3	21	14.0
	Fair (0.4–0.6)	32	23.5	25	16.7
	Good (0.7–1.0)	31	22.8	48	32.0
	Excellent (1.1 and Over)	40	29.4	56	37.3
Total		136	100.0	150	100.0
Hemoglobin Gm./100 Ml.	Poor[2]	0	0.0	3	2.0
	Fair[2]	27	19.9	28	18.5
	Good[2]	52	38.2	70	46.4
	Excellent[2]	57	41.9	50	33.1
Total		136	100.0	151	100.0
Hematocrit Value Per Cent	Poor (Below 33)	2	1.5	1	0.7
	Fair (33–39)	17	13.1	35	24.8
	Satisfactory (40 and Over)	111	85.4	105	74.5
Total		130	100.0	141	100.0
Plasma Protein Gm./100 Ml.	Poor (Below 6.0)	1	0.8	1	0.7
	Fair (6.0–6.4)	5	3.8	9	6.2
	Satisfactory (6.5 and Over)	124	95.4	136	93.2
Total		130	100.0	146	100.1

Table 5. Number and per cent of 14 through 16 year old boys and girls having levels of nutrition indicated by biochemical tests on blood.

[1] Based on ratings of Bessey and Lowry (7).
[2] Since hemoglobin values vary with age and sex the following ratings were used:

(Continued on page 267)

R rs	15 Year Old Girls		16 Year Old Boys		16 Year Old Girls	
Per Cent	No. of Cases	Per Cent	No. of Cases	Per Cent	No. of Cases	Per Cent
13.1	19	15.6	3	2.9	13	11.8
21.3	26	21.3	20	19.6	24	21.8
57.4	68	55.7	55	53.9	66	60.0
8.2	9	7.4	24	23.5	7	6.4
100.0	122	100.0	102	99.9	110	100.0
23.6	33	25.6	26	25.0	24	21.4
53.7	53	41.1	51	49.0	56	50.0
22.0	40	31.0	25	24.0	29	25.9
0.8	3	2.3	2	1.9	3	2.7
100.1	129	100.0	104	99.9	112	100.0
18.3	18	13.6	34	32.1	14	12.5
36.5	29	22.0	16	15.1	20	17.9
13.5	39	29.5	23	21.7	28	25.0
31.7	46	34.8	33	31.1	50	44.6
100.0	132	99.9	106	100.0	112	100.0
1.6	0	0.0	1	0.9	0	0.0
19.7	26	19.5	16	15.1	15	13.3
41.7	52	39.1	32	30.2	56	49.6
37.0	55	41.4	57	53.8	42	37.2
100.0	133	100.0	106	100.0	113	100.1
1.7	2	1.6	0	0.0	0	0.0
4.2	27	21.1	4	4.0	26	23.4
94.1	99	77.3	96	96.0	85	76.6
100.0	128	100.0	100	100.0	111	100.0
0.8	1	0.8	0	0.0	0	0.0
5.0	4	3.0	2	2.0	6	5.3
94.1	127	96.2	100	98.0	107	94.7
99.9	132	100.0	102	100.0	113	100.0

	Girls	*14 yr. Boys*	*15–16 yr. Boys*
Poor	Below 11.0	Below 11.5	Below 12.0
Fair	11.0–12.9	11.5–13.4	12.0–13.9
Good	13.0–13.9	13.5–14.4	14.0–14.9
Excellent	14.0 and over	14.5 and over	15.0 and over

peak in distribution was not as marked in serum ascorbic acid as it was in the case of some of the other nutrients. The results of the Oregon study were similar to those of the study on New York children in that values for hemoglobin for the boys increased with age. Furthermore, the mean values for hemoglobin for the boys were higher than those for the girls in the New York and Oregon studies. The results for the children of the two States were similar with respect to plasma or serum protein. From the uniformity of the results, it would appear that plasma or serum protein determinations are of questionable value in studies on nutritional status. Although plasma protein determinations were made in Oregon and serum protein was determined in the New York study, the results can be compared since, according to Van Slyke (8), the difference between serum and plasma protein values is not significant.

In a study on 436 children in five other counties in Oregon, Fincke (9) and her coworkers obtained values for hemoglobin which were similar to those reported in this paper. Their results also revealed that the values were higher for boys than for girls and that, for these particular age groups, the hemoglobin values for the boys increased with age but that those for the girls did not show an increase with age.

Table 6. Correlation coefficients[1] for pairs of biochemical tests based on 591[2] pairs of observations.

	Serum Carotene	Serum Ascorbic Acid	Hemoglobin	Hematocrit	Plasma Protein
Serum Vitamin A	+0.2334*	+0.1577*	+0.2107*	+0.1850*	+0.0527
Serum Carotene		+0.3916*	−0.0267	−0.0115	+0.0111
Serum Ascorbic Acid			−0.0704	−0.0381	−0.0078
Hemoglobin				+0.6688*	+0.0707
Hematocrit Value					+0.0200

[1] Significance levels for coefficient correlations with 591 pairs of observations: 0.08 at 5 per cent level; 0.11 at 1 per cent level.

[2] 591 is the number of children for whom data were obtained for all six blood constituents.

* Those which are statistically significant are significant at the 1 per cent level, or highly significant.

It was found that the mean hemoglobin values for Canadian boys and girls reported by Pett and Ogilvie (10) were lower than those obtained in the Oregon study for boys and girls of comparable age.

The hemoglobin levels of Parker High School children in South Carolina reported by Wilkins, Blakely, and Brunson (11), those of the children of Albemarle County, Virginia, reported by Englar, Blakely and Wilkins (12), and those of New York school children reported by Bessey and Lowry (7) are compared (Table 7) with the values obtained on the Oregon children included in this study. The data in this table show, in general, that the hemoglobin values for the New York and Oregon children were higher than those of the South Carolina and Virginia children. Also the relationship between age and hemoglobin in boys and the lack of relationship between age and hemoglobin in girls are illustrated.

Summary

This paper presents the results of determinations of serum vitamin A, serum carotene, serum ascorbic acid, hemoglobin, hematocrit value, and plasma protein for 14, 15, and 16 year old native born and reared school childern in two geographic regions (four counties) of Oregon. Blood samples were obtained by finger puncture from 766 children. The micromethods of Bessey and Lowry were used in making the above determinations.

The results were analyzed to determine whether or not there were any relationships between each of the biochemical tests and age and sex of the children as well as residence, in terms of County and Region.

The majority of the children had high values for all of the six blood constituents with the exception of serum carotene in which case about 50 per cent of the children were classified as "fair." There were, however, an appreciable number of the subjects who rated low for several of the blood tests.

By means of analysis of variance, regional differences were

	Boys							
	14		15		16		14	
	No. of Cases	Mean	No. of Cases	Mean	No. of Cases	Mean	No. of Cases	
Albemarle County, Virginia	*	13.6	*	14.2	*	14.6	*	
Parker High School, South Carolina	121	12.6	141	13.0	140	13.5	132	
New York	116	14.3	127	14.6	73	14.5	159	
Oregon	136	14.3	127	14.7	106	15.1	151	

Table 7. Values for hemoglobin for children, classified by age and sex, for Parker High School,[1] Albemarle County,[1] New York[1] and Oregon.

[1] Values for hemoglobin for specific sex and age groups were read from graphs.

* The number of boys and girls included were not classified by age in the report, however, a total of 403 boys and 579 girls, from 9 through 17 years of age and above, were included in the study.

found in the values for serum vitamin A, hemoglobin, and hematocrit value; the values for those constituents for the Central Oregon children were higher than for the children living in the Coast Region. Regional differences were not found in the values for serum carotene, serum ascorbic acid, and plasma protein.

Intraregional differences and similarities were determined by analysis of variance. The values for serum vitamin A for the children of Coos County were higher than those for the Clatsop County children, whereas the Clatsop County children had the higher hemoglobin values. The children of the two counties did not differ significantly with respect to the results of the other four blood constituents. Statistical analysis of the results for Deschutes and Klamath Counties revealed that the children of Klamath County had higher values than the Deschutes County children for hemoglobin and hematocrit value, whereas the children of Deschutes County had the higher values for serum carotene, serum ascorbic acid, and plasma protein. The values for serum vitamin A for the children of the two counties did not differ significantly.

When age alone was considered, there was a relationship

	16	
Mean	No. of Cases	Mean
13.2	*	12.9
12.1	127	12.3
13.5	77	13.4
13.7	113	13.7

between age and the values for serum vitamin A, hemoglobin, and hematocrit value.

The sex differences in hemoglobin were found to be highly significant statistically; the boys had the higher values.

For boys, the values for hemoglobin increased with age. The hemoglobin values for the girls did not show an increase with age but either decreased, remained about the same, or were inconsistent with age.

Comparable studies on 14, 15, and 16 year old children in New York, South Carolina, and Virginia showed that the mean hemoglobin values for the children of New York and Oregon were higher than those of the South Carolina and Virginia children.

Correlation coefficients were calculated to determine the relationship between pairs of biochemical tests. Statistically significant correlation coefficients were obtained for serum vitamin A and serum carotene, serum vitamin A and serum ascorbic acid, serum vitamin A and hemoglobin, serum vitamin A and hematocrit value, serum carotene and serum ascorbic acid, and hemoglobin and hematocrit value. The correlation coefficients for serum vitamin A and plasma protein, serum carotene and hemoglobin, serum carotene and hematocrit value, serum carotene and plasma protein, serum ascorbic acid and hemoglobin, serum ascorbic acid and hematocrit value, serum ascorbic acid and plasma protein, hemoglobin and plasma protein and for hematocrit value and plasma protein were not statistically significant.

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