Blood Studies in Puerto Rican Children[1]

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BLOOD studies in apparently healthy children have never been reported in Puerto Rico. Up to a few years ago it was the general consensus of opinion among local physicians that for some unknown reasons, perhaps climatic, blood values in this island were unduly low. In 1931 Pons[2] studied 180 indigent individuals of various age groups admitted to the University Hospital of the School of Tropical Medicine, and found a hemoglobin average of 71.5 percent and a count of red blood cells averaging 4.05 millions per cubic millimeter. The conclusion was reached that blood values among Puerto Ricans were not necessarily lower than elsewhere. Suárez and Costa Mandry,[3] from a study of healthy adult Puerto Ricans, concluded:

> . . . the number of erythrocytes, hemoglobin content, and volume of packed red blood cells is very similar in the case of healthy Puerto Rican males to that estimated in other countries by different investigators. In females the figures are very similar to those obtained elsewhere except for a moderate reduction in the hemoglobin content.

More recent studies by Rodríguez-Molina and associates[4] of over five hundred Puerto Rican soldiers show a high percentage of hemoglobin and a red cell count comparable to the values obtained in normal adults in other parts of the world. This work appears to prove beyond doubt that under adequate nutritional conditions, Puerto Ricans do not necessarily present subnormal blood values, as previously believed; furthermore, that the anemias frequently observed in Puerto Rico are not influenced at all by climatic or other geographical conditions, but rather by chronic malnutrition and parasitic infestations.

MATERIAL, METHODS, AND CLASSIFICATION

The work was carried out on a group of white and colored females ranging from eight to eighteen years of age, consisting of two groups

1. Received for publication September 26, 1941.

2. Juan A Pons, "The Red Cell Count and Hemoglobin in Puerto Rico from an Analysis of Hospital Cases," *Puerto Rico J.Pub.Health & Trop.Med.*, VII (Dec., 1931), 203.

3. Ramón Suárez and O. Costa Mandry, "Hematological Studies in Puerto Ricans," *Tr.Roy.Soc.Trop.Med. & Hyg.*, XXVII No. 6 (May, 1934), 579.

4. R. Rodríguez Molina *et al.* To be published.

of fifty-two, selected as the average with respect to their ages and weights from 263 women enrolled at a Government charity institution. Two seven-day dietary studies were conducted by the Department of Chemistry of the School of Tropical Medicine for the determination of the quantity and quality of the food consumed.[5]

The following blood examinations were performed: enumeration of erythrocytes, including study of the stained smear; estimation of hemoglobin; and determination of the volume of packed red blood cells. Mean corpuscular volume, mean corpuscular hemoglobin, and mean corpuscular hemoglobin concentration were calculated from these values. Three cubic centimeter samples of venous blood were drawn from a vein at the elbow flexure of each subject. In order to avoid stasis the tourniquet was released as soon as the vein had been punctured. The blood was rendered incoagulable by the addition of a mixture of dry potassium and ammonium oxalate (4 mg. of the former and 6 mg. of the latter for every cubic centimeter of blood). The corpuscular counts were made according to the usual technique, using certified apparatus. The mean of two corpuscular counts and of two hemoglobin determinations was recorded for each case. Smears for the study of red and white cell morphology were prepared immediately, as soon as the blood had been obtained. A single Hellige-Wintrobe hemometer, with a solid standard so calibrated that 14.5 grams of hemoglobin were equivalent to 100 percent, was used. Wintrobe's hematocrit[6] was employed to determine the volume of packed red blood cells, and the most recent classification of the anemias presented by him was followed.[7] According to his experience the following constant values are considered normal:

1. Volume of Packed Red Blood Cells
   - *a*) Men 40 to 50 cc. per 100 cc. of blood
   - *b*) Women 37 to 45 cc. per 100 cc. of blood
2. Mean Corpuscular Volume
   - *a*) 82 to 94 cubic microns
3. Mean Corpuscular Hemoglobin
   - *a*) 27 to 31 micromicrograms
4. Mean Corpuscular Hemoglobin Concentration
   - *a*) 32 to 36 percent

5. J. H Axtmayer, unpublished data.
6. M. M. Wintrobe, "A Simple and Accurate Hematocrit," *J.Lab.& Clin.Med.*, XV (Dec., 1929), 287.
7. M. M. Wintrobe, "Macroscopic Examination of Blood; Discussion of Its Value and Description of One Single Instrument for Determination of Sedimentation Rate, Volume of Packed Red Cells, Leukocytes and Platelets, and of Icteric Index," *Am.J.M.Sc.*, CLXXXV (Jan., 1933), 58.

On the basis of the above values Wintrobe has presented the following laboratory classification of the anemias:[8]

1. Macrocytic anemia: cases in which the mean corpuscular volume is greater than 94 cubic microns and the mean corpuscular hemoglobin concentration is 30 percent or higher.
2. Normocytic anemia: those cases with a mean corpuscular volume ranging from 80 to 94 cubic microns and a mean corpuscular hemoglobin concentration of 30 percent or more.
3. Microcytic anemia: cases in which the mean corpuscular volume is less than 80 cubic microns and the mean corpuscular hemoglobin concentration is 30 percent or higher.
4. Hypochromic anemia: cases with a mean corpuscular hemoglobin concentration of 29 percent or less, whether the mean corpuscular volume is greatly or slightly reduced or even normal.

More recently Haden[9] has classified the anemias on the basis of the size and the hemoglobin content of the mean red cell into:

1. Normocytic and normochromic
2. Normocytic and hypochromic
3. Macrocytic and hyperchromic
4. Macrocytic and normochromic
5. Macrocytic and hypochromic
6. Microcytic and hypochromic

RESULTS AND DISCUSSION

The mean erythrocyte count was 4.33 millions per cmm., with values ranging from 2.88 to 5.48 millions per cmm. The hemoglobin content varied from a minimum of 9.2 grams to a maximum of 16.3 grams with a mean value of 12.06 grams per 100 cc. of blood. The volume of packed red blood cells varied from 36 to 47 cc. The mean corpuscular volume for the group was 96 cubic microns with values ranging from 77 to 138 cubic microns. The lowest mean corpuscular hemoglobin was 19 micromicrograms and the highest, 44 with a mean figure of 31 micromicrograms. The mean corpuscular hemoglobin concentration was 29 percent, the lowest 23, and the highest 34 percent.

In seventy-three girls (70 percent) the red cell count was above 4 millions per cmm.; forty-two girls (40 percent) had corpuscular

8. *Ibid.*
9. R. L. Haden, "The Diagnostic Significance of Changes in the Red Cells," *Bul.New York Acad.Med.*, XV (May, 1939), 291.

counts greater than 4.5 millions; and in ten (9 percent) the count was over 5 millions per cmm.

In thirty (28.2 percent) instances the red cell count was between 3 and 4 millions, and in only one case was the count lower than 3 millions. The hemoglobin content was higher than 10.9 grams in eighty-three girls (79 percent); in forty (38 percent) the hemoglobin was above 12.5 grams; in twenty-six (25 percent) it was greater than 13 grams. In nine girls (8.9 percent) the content was between 10 and 10.5 grams, and in four instances (4 percent) it varied between 9.5 and 10 grams. In 100 girls the volume of packed red cells was higher than 37 cc. In forty-six cases (44 percent) it ranged between 35 and 40 cc. The mean corpuscular volume was above 80 cubic microns in ninety-four cases (90 percent). In one case it was below 75; in nine (8.9 percent), between 75 and 80; in ten (9 percent), between 80 and 85; in seventeen (16 percent) it ranged from 85 to 90; in twenty (19 percent) from 90 to 95; in twenty-one (20 percent) from 95 to 100; and in twenty-five (24 percent) it was over 100 cubic microns. The mean corpuscular hemoglobin varied from 20 to 25 micromicrograms in twenty-nine girls (27.8 percent); from 25 to 30 in fifty (48 percent); and in twenty-two cases (21 percent) it was between 30 and 35 micromicrograms. In only two (1.9 percent) was it below 20 but above 15 micromicrograms. The mean corpuscular hemoglobin concentration varied from 20 to 25 percent in five girls (4.9 percent); from 25 to 30 percent in sixty-nine (66 percent); and from 30 to 35 percent in thirty cases (28.8 percent). Axtmayer says:

> The two seven-days dietary studies conducted revealed that the daily intake of food averaged 1523.4 calories, an intake far from sufficient to meet the requirements of an actively growing organism. These studies also showed that the girls were ingesting a daily average of 54.8 grams of protein, 0.775 gram of calcium, 1.01 gram of phosphorus and 0.040 grams of iron. Although these quantities of essential nutrients might meet the minimum requirements, they are below the quantities stipulated as required for optimum growth and well-being.
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> The average fat value of the diet fed was too high, yielding an average of 25.5 percent of the total caloric value of the food ingested. A bio-assay of the diet showed a vitamin A content of only 0.7 Sherman Unit per gram for the food mixture or a total of 1070 units for the day. The vitamin A requirement indicated by Stiebling's survey is satisfied by an intake of 3500 to 4000 Sherman Units per day.
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> Although no determinations were made for the vitamin-C content, the diet is to be judged deficient in this factor because most of it was highly cooked in open kettles, and the quantities of bananas, oranges, tomato, lettuce and other good sources of this vitamin known to be consumed were small. The possibility of a low intake of the vitamin B complex and of vitamin D is also indicated from the nature of the diet.[10]

According to the results of the blood studies performed, the cases studied can be classified into the following groups:

Types of Anemia	*No. of Cases*	*Percent of Total*
1. Macrocytic	28	26.92
2. Hypochromic	29	27.88
3. Normocytic	2	1.93
Normal Blood Values	19	18.27
	78	75.00

There remain twenty-six cases (25 percent) in which the mean corpuscular volume was greater than 94 cubic microns, but the mean corpuscular hemoglobin concentration was below 29 percent. According to Wintrobe's classification of the anemias, this group does not fit into any of the various types of anemias. However, in a study carried on by this investigator in twenty-four cases of sprue and pernicious anemia[11] in which 100 hematocrit studies were performed, in eleven instances the mean corpuscular hemoglobin concentration was reported as being below 29 percent. These cases were classified under macrocytic anemia, and were considered very infrequent. Wintrobe believes further[12] that such cases are due to an error in technique and rarely to the simultaneous occurrence of a deficiency of iron and antipernicious anemia factor. We firmly believe that the latter is a more logical explanation than the former. Frequently a high mean corpuscular volume and a low mean corpuscular hemoglobin concentration have been observed in our sprue patients at the University Hospital. Suárez[13] has obtained similar results in nearly 50 percent of twenty-five cases of sprue; more recently

10. J. H. Axtmayer, *loc. cit.*
11. M. M. Wintrobe, "The Hemoglobin Content, Volume and Thickness of the Red Blood Corpuscles in Pernicious Anemia and Sprue, and the Changes Associated with Liver Therapy," *Am.J.M.Sc.*, CLXXXI (Feb., 1931), 217.
12. M. M. Wintrobe, written communication to R. Rodríguez Molina.
13. Ramón Suárez, "Hematological Studies in Sprue," *Bol.Asoc.Méd.de Puerto Rico*, XXVII (Oct., 1935), 239.