Normal Values for Haemoglobin Concentration and Red Cell Indices in Preschool Children on the Highveld

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SUMMARY

Data on haemoglobin concentration, red cell count, packed cell volume, mean cell volume, mean cell haemoglobin and mean cell haemoglobin concentration for ‘normal’ children aged 1 - 4 years living on the Highveld (altitude 1400 - 1800 m) are presented in yearly age groups. The children were defined as normal on the basis of having growth attainment and iron, folate and vitamin B12 nutrition within accepted normal limits. The results obtained differ from the standard reference values published for children resident at sea level. It is suggested that the mean (± 2 SD) ranges presented be used as normal ranges in the population studied.


The establishment of a normal range is essential for the detection of disease in individual subjects, and for epidemiological surveys. Normal ranges for haematological values are available for preschool children living at sea level, but to our knowledge, there are no figures available for local preschool children living at altitudes above sea level. In view of the effect of increasing altitude on the erythron, values at sea level can only be applied to subjects living at higher altitudes by a crude extrapolation. To meet this lack, normal ranges for a number of haematological tests on healthy preschool children living on the Highveld (altitude 1400 - 1800 m) have been compiled.

Since haemoglobin concentration and red cell indices change rapidly with age in young children, the children were examined in yearly age groups. Furthermore, since iron deficiency is a major problem at this age, great care was taken to exclude iron-deficient children from the study group.

SUBJECTS AND METHODS

Selection of Subjects

In compiling normal ranges for laboratory measurements, great care needs to be taken in defining the ‘normal’ population from which the data are to be derived. The normal population was selected according to the method of Viteri et al.' Original surveys were carried out on random samples of the population and the normal group subselected by excluding those children who were malnourished. During the course of three nutrition status surveys at Muldersdrift' and Western Township, a sub-
group of 181 children aged 13 - 60 months was selected in this manner. This subgroup was composed of children whose growth, and iron, folate and vitamin B12 nutrition were within normal limits, as defined below. The Muldersdrift and Nqutu children were Black and those in Western Township were Coloured. They all lived at an altitude ranging from 1 400 to 1 800 m above sea level.

**Laboratory Methods**

Haemoglobin concentration, red cell count, haematocrit, mean cell volume (MCV), mean cell haemoglobin (MCH) and mean cell haemoglobin concentration (MCHC) were measured using Coulter equipment. In the Muldersdrift and Western Township studies a model 'S' was used and at Nqutu, a model 'F' in conjunction with a Coulter haemoglobinometer and MCV/haematocrit attachment. The machines were calibrated with a Coulter '4C' standard for each batch of determinations. In the Coulter system, haemoglobin concentration, red cell count and MCV are measured directly; the other indices are calculated.

Serum iron concentration was measured by the ICSH method scaled down to use 0,25 ml of serum per test, and the percentage saturation of transferrin, calculated from unsaturated iron-binding capacity or from the direct measurement of transferrin by immunodiffusion. Serum and red cell folate were measured by microbiological assay by the methods of Herbert et al. respectively. Serum vitamin B12 was measured by a radioisotope dilution method using chicken serum as binder.

**Definition of Normal Growth and Haematological Nutrition**

Growth was assessed by body mass, and the Boston 3rd percentile was taken as the lower limit of normal. Children were considered to have normal iron nutrition if their serum iron concentration was greater than 50 μg/100 ml and their saturation of transferrin greater than 18%. In the Muldersdrift group, folate status was assessed by serum folate assay and 3,0 ng/ml was taken as the lower normal limit. In the other two areas, red cell folate measurements were done and a concentration of 160 ng/ml was used as the lower limit. A value of 400 pg/ml was taken as the lower limit for serum vitamin B12.

**Statistical Method**

The statistical method used to define the normal ranges for haemoglobin concentration and the red cell indices is based on a well-known property of the Gaussian distribution, viz. that the range defined by the mean ± 2 standard deviations includes the middle 95% of the distribution, leaving 2.5% of observations at either tail. People whose measurements fall out of this range on either side have a less than 2.5% probability of belonging to the normal population.

**RESULTS**

There were no statistically significant differences in the haematological values measured between children of either sex or from the different areas, and the data were thus analysed as a single group.

The number of children in each group, together with the results of the haematological investigations, is presented in Table 1.

The mean haemoglobin value was 12,1 g/100 ml in the 13 - 24-month age group. It increased by an average of 0,3 g/100 ml per year, reaching 12,9 g/100 ml in the 49 - 60-month age group. The mean red cell count showed no significant age-related changes.

The changes in the mean haematocrit value with age paralleled those in haemoglobin level. Thus, the lowest (36,5%) occurred in the 13 - 24-month age group and rose steadily to 38,5% in the 49 - 60-month age group.

There were marked age-related changes in the mean values for MCV. From an initial mean value of 78 fl in the 13 - 24-month age group, the MCV increased with age to 83 fl by 37 - 48 months, after which no further increase was observed. The changes in mean values for the MCH paralleled those in MCV. From a mean value of 25,6 pg in the 13 - 24-month age group, the MCV rose by 1 pg for each year, reaching a mean value of 27,6 pg in the 37 - 48-month age group, after which there was also no further increase in the MCH. In contrast to the MCH, the MCHC did not change significantly with age.

All the data were submitted to statistical analysis. The rise in the mean values for haemoglobin, haematocrit, MCV and MCH was statistically significant when the 13 - 24-month and the 49 - 60-month age groups were compared (α = 0,05, P<0,001). There were no significant age-related changes in the red cell count or MCHC.

In Table II, the mean values for the parameters tested are compared with reference values for infants and children resident at sea level. The reference data are derived from infants and children in whom haematinic deficiency was not rigidly excluded as in the present study; as such, comparison of the data must be treated with reserve.

A similar pattern of age-related changes is evident in...
Department has shown that an overlap occurred between haematocrit levels of resident and rigorously excluded haematinic deficiency. With regard to the other values, Garby's work has divided these subjects into two groups, one at sea level and the other at altitude for all age groups. These observations are similar to those reported in the literature for young children studied into yearly age groups, and with those in the present study, in view of the changes that occur in haematological values during the 12-48-month age period. With regard to altitude, despite the well-known effects of increasing altitude and of malnutrition on haematological values, the only other study of haemoglobin values and red cell indices in preschool children, known to us, which took altitude into account and rigorously excluded haematinic deficiency, was that of Viteri et al. These workers did not divide the young children studied into yearly age groups, and presented their data for a combined group of young children aged 12-48 months. These data cannot be compared with those in the present study, in view of the changes with age which occur in haematological values during the 12-48-month age period. With regard to altitude, Viteri et al. divided these subjects into two groups, one resident at 0-750 m and the other at 751-1500 m above sea level. Mean values for haemoglobin, haematocrit and red cell count were greater in the group resident on the higher altitude. These observations are similar to those found when the data from the present study are compared with the reference values for children resident at sea level.

The observation of a rise in haemoglobin, haematocrit, MCV and MCH with increasing age in iron-replete children is of interest in that it indicates that young children can have red cell indices which, in an adult, would be in the microcytic hypochromic range. Clinicians not aware of this may erroneously diagnose iron deficiency in an iron-replete child and administer therapy unnecessarily.

The normal range for haematological values must be interpreted correctly, because an overlap frequently occurs in the measurements of 'normal' and diseased people. For example, Garby has shown that an overlap occurred in the initial haemoglobin concentration of subjects who did, and others who did not, show a haemopoietic response to iron administration. If a subject's haemoglobin concentration fell in this overlap range, it would be possible to calculate the probability of his being anaemic, but the diagnosis of anaemia could not be conclusive.

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TABLE II. MEAN VALUES AT ALTITUDE COMPARED WITH PUBLISHED REFERENCE VALUES

<table>
<thead>
<tr>
<th>Age (months)</th>
<th>Haemoglobin (g/100 ml)</th>
<th>Red cell count (10^6/μl)</th>
<th>Haematocrit (%)</th>
<th>MCV (fl)</th>
<th>MCH (pg)</th>
<th>MCHC (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PS</td>
<td>Ref</td>
<td>PS</td>
<td>Ref</td>
<td>PS</td>
<td>Ref</td>
</tr>
<tr>
<td>13 - 24</td>
<td>12.1</td>
<td>11.2</td>
<td>4.7</td>
<td>4.5</td>
<td>37</td>
<td>35</td>
</tr>
<tr>
<td>25 - 36</td>
<td>12.3</td>
<td>11.5</td>
<td>4.7</td>
<td>4.6</td>
<td>37</td>
<td>35</td>
</tr>
<tr>
<td>37 - 48</td>
<td>12.6</td>
<td>12.5</td>
<td>4.6</td>
<td>4.5</td>
<td>38</td>
<td>36</td>
</tr>
<tr>
<td>49 - 60</td>
<td>12.9</td>
<td>12.6</td>
<td>4.7</td>
<td>4.6</td>
<td>39</td>
<td>37</td>
</tr>
</tbody>
</table>

DISCUSSION

The results of the present study indicate that the reference normal ranges for haemoglobin concentration and red cell indices are not directly applicable to young children resident at high altitude. Mean values for haemoglobin concentration, red cell count and haematocrit are consistently higher for children living at altitude, and it is suggested that the present data replace the existing normal ranges as reference values for young children resident on the highveld.

Despite the well-known effects of increasing altitude and of malnutrition on haematological values, the only other study of haemoglobin values and red cell indices in preschool children, known to us, which took altitude into account and rigorously excluded haematinic deficiency, was that of Viteri et al. These workers did not divide the young children studied into yearly age groups, and presented their data for a combined group of young children aged 12-48 months. These data cannot be compared with those in the present study, in view of the changes with age which occur in haematological values during the 12-48-month age period. With regard to altitude, Viteri et al. divided these subjects into two groups, one resident at 0-750 m and the other at 751-1500 m above sea level. Mean values for haemoglobin, haematocrit and red cell count were greater in the group resident on the higher altitude. These observations are similar to those found when the data from the present study are compared with the reference values for children resident at sea level.

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REFERENCES