HAEMATOLOGICAL CHARACTERISTICS AT MODERATE ALTITUDE IN RWANDA

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ABSTRACT

Background: Haematological adaptation to altitude varies according to populations. We report a study on haematological values in a student population in Butare, Rwanda (altitude: 1768 m; barometric pressure: 629 mm Hg).

Objective: To illustrate haematological adaptation to moderate altitude.

Setting: Laboratories of physiology and haematology, Butare University Teaching Hospital, Rwanda.

Subjects and methods: Healthy young adults were randomly chosen among students of the National University of Rwanda to participate in the study. Radiometer OSM2b Haemoximeter was used to determine haemoglobin concentration. Haematocrit was determined by the micromethod using haematocrit capillaries. The red cell counting was done by the microscopic manual method with a Neubauer haematimeter. Mean cell volume, mean cell haemoglobin and mean cell haemoglobin concentration were calculated from red cell count, haematocrit and haemoglobin concentration.

Results: The results – mean and reference range (2.5^{th}–97.5^{th} percentiles) in brackets – are as follows: haemoglobin concentration; males: 156 (136-177) g/L, females: 132 (114-150) g/L; haematocrit: males: 49.0 (43-54) %, females: 42.6 (36-48) %; red cell count: males: 5.01 (4.05-5.75) X 10^{12}/L, females: 4.31 (3.7-4.9) X10^{12}/L; mean cell volume: males: 97 (88-105) fL, females: 96 (87-104) fL; mean cell haemoglobin: males: 31.1 (26-36) pg; females: 30.6 (25-35) pg; mean cell haemoglobin concentration: males: 31.8 (27-36) g/dL; females: 31.0 (26-35) g/dL.

Conclusion: The results show a normal haemoglobin concentration, a normal red cell count, an increase in haematocrit and mean cell volume, a normal mean cell haemoglobin and a low mean cell haemoglobin concentration.

Key words: Rwanda, altitude, haematology

INTRODUCTION

It is well established that altitude hypoxemia due to a lowering of P_aO_2 and an insufficient oxygen saturation of haemoglobin, provokes an increase in red cell count, haematocrit and haemoglobin concentration. However, altitude haematological changes are variable according to populations, even at same altitude.[1,2,3]

In order to study the physiological adaptation to the moderate altitude in Rwanda, we carried out a study in students of the National University of Rwanda, located in Butare (altitude: 1768 m, barometric pressure: 629 mm Hg). We present here results for haematological parameters.

SUBJECTS AND METHODS

This study was carried out in the laboratories of Physiology and Haematology, Department of Medical Biology, Butare University Teaching Hospital and Faculty of Medicine, National University of Rwanda. The test subjects were selected randomly with Epi-Info 6.04 software. The objectives of the study, the nature and the conditions of sampling and the voluntary character of participation in the study were clearly explained. Selected test subjects were young healthy adults, age range 20–37 years for males and 20–35 years for females. They had a normal arterial pressure. They had spent at least one year in Butare and had permanently stayed there for the four weeks preceding the sampling. Females were not pregnant, not in the menses period, not breastfeeding and not on contraception. All test subjects were non-smokers. There was no apparent disease on anamnesis and physical examination. The absence of malaria, infection, verminosis or use of drugs in the month preceding the sampling was checked during anamnesis. Most of test subjects were non-drinkers, some drank beer only occasionally. The test subjects were asked to do no physical exercise in the morning of the sampling. The sampling was done on subjects in physical rest for at least 10 minutes, after overnight fasting. Arterial blood was sampled from the radial artery on subjects in supine position, with heparin 5000 IU/mL as anticoagulant, without local anaesthesia, with single use 5 mL plastic syringes and 21 gauge needles. Venous blood for haematocrit and erythrocyte counting was sampled from the cubital vein on subjects in sitting position, in a tube with ethylenediaminetetraacetic acid (EDTA) as anticoagulant.

Arterial haemoglobin concentration was measured photometrically with a Radiometer OSM2b Haemoximeter. Calibration, quality control, measurements and maintenance procedures were carried out according to instructions of the manufacturer (Radiometer, Copenhagen, Denmark). Venous haemoglobin concentration was obtained by increasing the arterial value by 1.4% [4].

Haematocrit was determined by the micromethod using Hirschmann haematocrit capillaries, a Hettich type centrifuge and a microscale. The red cell counting was done by the manual method with a Neubauer haematimeter, by microscopy, objective X 40. The mean cell volume, the mean cell haemoglobin and the mean cell haemoglobin concentration were calculated respectively from haematocrit and red cell count, haemoglobin concentration and red cell count, and haemoglobin concentration and haematocrit, with appropriate formulas. Means, standard deviations and percentiles were determined with Microsoft Excel software.

RESULTS

The mean age is 26 years for males and 25 years for females. The weight (mean ± SD) is 63.7 ± 7.3 kg in males and 59.9 ± 8.2 kg in females. Haematological results are presented in table 1 as means, SD and 2.5^{th} – 97.5^{th} percentile ranges.

Table 1. Venous blood mean values and reference ranges

	Hb (g/L)		Haematocrit (%)		RBC ($X10^{12}$/L)		MCV (fL)		MCH (pg)		MCHC g/dL	
Sex	M	F	M	F	M	F	M	F	M	F	M	F
N	170	98	142	98	170	98	142	98	170	98	142	98
Mean	156	132	49.0	42.6	5.01	4.31	97	96	31.1	30.6	31.8	31.0
SD	10	10	3.0	2.9	0.40	0.31	4.2	4.3	2.6	2.6	2.3	2.4
2.5^{th}-97.5^{th} percentile	136-177	114-150	43-54	36-48	4.05-5.75	3.7-4.9	88-105	87-104	26-36	25-35	27-36	26-35

Hb = haemoglobin concentration; RBC = red cell count; MCV = mean cell volume; MCH = mean cell haemoglobin; MCHC = mean cell haemoglobin concentration; M = males; F = females; N = number of subjects; SD = standard deviation.

DISCUSSION

In a previous report[5] we showed that, despite P_aO_2 lower than at sea level, there is good oxygen saturation of haemoglobin at Butare altitude. The absence of hypoxemia explains the normal red blood cell count observed in this study. Such normal haematological findings have been reported in other studies in highland natives. At higher altitudes, haemoglobin levels are increased[6].

Our haematocrit values are increased, as compared to classical reference intervals.[7,8,9] At 2400 m in the Ethiopian highlands, Tsegaye et al.[3] found erythrocyte counts of 5.1 X 10^{12}/L in males and 4.5 X 10^{12}/L in females; haemoglobin concentration: 16.1 g/dL in males and 14.3 g/dL in females; haematocrit: 48.3% in males and 42.0% in females. In another study on Ethiopian highland natives, Beall et al.[1] found at 3530 m a haemoglobin concentration of 15.9 and 15.0 g/dL in males and females respectively. An increase of haemoglobin concentration, haematocrit, red cell count and mean cell volume was observed at a slightly higher altitude of 1869 m in 7-14 year old children in Turkey.[10]

The increase in mean cell volume in our study results from the increase in haematocrit without accompanying increase in red blood cell count. The normal haemoglobin concentration with normal red cell count results in normal mean cell haemoglobin and, with increased haematocrit, in a low mean cell haemoglobin concentration.

Our study carried out in a well-nourished student population permits to illustrate haematological adaptation to the moderate altitude of Butare.

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