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Haematological Studies in High Altitude Natives at Plains and on Return to High Altitude

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ABSTRACT

Haematologic studies were carried out in 20 high altitude natives during two months stay at plains (200 m) and on their return to an altitude of 3,500 m. Haemoglobin, erythrocyte count, haematocrit and reticulocyte count decreased rapidly on arrival to plains and attained minimum level by the end of fourth week. All these parameters increased rapidly on return to high altitude and were found to attain maximum values by 23rd day on return to high altitude. Mean cell volume and mean cell haemoglobin showed significant increase at altitude. Blood volume and red cell mass increased significantly at altitude. It is concluded that the high altitude natives of Ladakh were well adapted to hypoxic environment due to normocythaemic hypervolemia.

1. INTRODUCTION

Men born and brought up in high altitude areas are expected to be fully acclimatised to high altitude. The observed polycythemia in natives and sojourns at high altitude is considered to be one of the most important mechanisms for high altitude acclimatisation[1-3]. It has been reported that Sherpas living permanently at 3800–3900 m are well adapted to high altitude on account of less haemoconcentration as compared to sojourners on prolonged stay[4]. However, no such study in Ladakhi soldiers has been reported in the literature.

2. MATERIALS AND METHODS

Studies were carried out on 20 young, healthy Ladakhi soldiers. They were born and brought up at altitude higher than 3,000 m and had never been to plains.

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The subjects were divided into two groups of 10 each (group I and II) and were brought down to plains (200 m) by air. Various haematological parameters were studied in group I at plains. After 2 months of stay in the plains, the subjects of both the groups were airlifted back to their place of origin at an altitude of 3,500 m. All the haematological parameters except red blood cell (RBC) life span, blood volume, red cell mass and plasma volume were studied in group II at high altitude.

The haematological parameters of the subjects were measured on 3rd, 7th, 11th, 16th, 24th and 31st day of stay at plains and on 3rd, 9th, 16th, 23rd, 28th and 38th day of induction to high altitude. Haemoglobin and RBC counts were determined using Hellige Erymat. Haematocrit was measured by the method of Wintrobe and reticulocyte count was determined using brilliant cresyl blue stain. Serum bilirubin was measured by the method of Malloy and Evelyn[4]. Blood volume and RBC life span were determined by *invitro* tagging of RBCs with radiochromium (^{51}Cr) using 'Wash-cell' technique[5]. Tagging of erythrocytes with ^{51}Cr was done on 14th day of stay at plains and after returning to altitude. Erythrocyte osmotic fragility of the fresh blood was determined by the method of Parpart *et al*[6]

3. RESULTS

The sequential changes in haemoglobin, red blood cell count, haematocrit and reticulocyte count are shown in Fig. 1. Haemoglobin, RBC count, haematocrit and

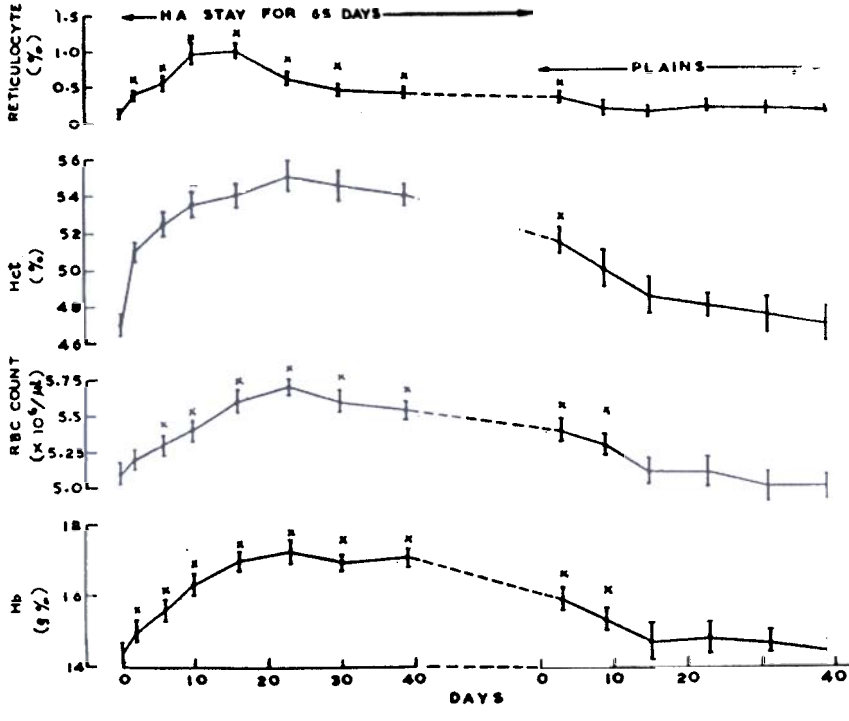

Figure 1. Sequential changes in haemoglobin; red blood cell count; haematocrit and reticulocyte count in high altitude natives at plains and on return to high altitude.

reticulocyte count decreased rapidly on arrival to plains and attained minimum levels by the end of the fourth week. Haemoglobin, RBC count and haematocrit attained maximum values by 23rd day of return to high altitude.

The mean maximum values of various parameters studied during stay at plains and mean minimum values on return to high altitude are compared in Table 1. Mean

Table 1. Haematological changes (mean ± SEM) in high altitude natives at plains and on return to high altitude

Parameters	High altitude natives at plains (n=10) (a)	High altitude natives at high altitude (n=10) (b)	Significance b vs a
Haemoglobin (g%)	13.3 ± 0.2	15.9 ± 0.2	P<0.001
RBC count ($X10^6/\mu l$)	4.80 ± 0.10	5.35 ± 0.05	P<0.001
Haematocrit (%)	42.3 ± 0.8	52.5 ± 0.6	P<0.001
Reticulocyte count (%)	0.12 ± 0.02	0.30 ± 0.03	P<0.001
MCV (μm^3)	88.1 ± 1.5	98.2 ± 0.8	P<0.001
MCH ($10^{-12}g$)	27.6 ± 0.3	29.7 ± 0.4	P<0.01
MCHC (%)	31.4 ± 0.5	30.2 ± 0.4	NS
Blood vol. (l)	4.577 ± 0.102	4.857 ± 0.175	P<0.05
Plasma vol. (l)	2.799 ± 0.070	2.629 ± 0.101	NS
Red cell mass (l)	1.778 ± 0.061	2.228 ± 0.091	P<0.005
RBC life span (d)	112.8 ± 6.2	106.2 ± 3.1	NS
Serum bilirubin (mg%)	0.73 ± 0.21	0.38 ± 0.03	P<0.01
Osmotic fragility (50% lysis in % NaCl)	0.44 ± 0.01	0.45 ± 0.01	NS

Hb, RBC, Hct and reticulocyte count showed a significant increase on return to high altitude (P<0.001). The MCV and MCH were also found to be significantly increased on return to high altitude but without any significant change in MCHC.

Blood volume and red cell mass were found to increase by 6.1 per cent (P<0.05) and 25.3 per cent (P<0.005) respectively. No changes in plasma volume, RBC life span and erythrocyte's osmotic fragility were observed. Serum bilirubin was found to be maximum during the first week of stay at plains and decreased on return to high altitude.

4. DISCUSSION

Polycythemia is a well observed phenomenon on prolonged or permanent stay at high altitude and is one of the most important adaptive mechanisms for high altitude acclimatisation[3,7].

In the present study carried out on high altitude natives of Ladakh on descent to plains, haemoglobin, haematocrit, RBC count and reticulocyte count were found to decrease rapidly. Similar observations were made by Reynafarje[3] and Merino[8]. The observed increase in serum bilirubin suggested an increased red cell destruction on descent to plains.

On return to high altitude after two months stay in plains, the high altitude natives exhibited an increased erythropoiesis. Similar observations were also made in plain-dwellers on induction to high altitude by a number of workers[9-11]. Blood volume and red cell mass were found to be significantly increased on the 14th day of return to altitude with an insignificant decrease in plasma volume. This would mean a relatively less increase in haematocrit and hence viscosity of blood. This may be considered beneficial from haemodynamic view point since it will result in less resistance to blood flow[12-15]. Our earlier studies on rabbits raised at high altitude for three generations also suggested that normocythaemic hypervolemia is of adaptive importance[14].

The haemoglobin concentration of the high altitude natives of Ladakh was found to be 15.9 ± 0.29 per cent which is comparable to those of Sherpa population living[16] permanently at 3,800–3900 m, but is much less than that of Andean high altitude population[2,3]. Morpurge *et al.*[16] observed that the Andeans are poorly adapted to hypoxia as shown by pronounced polycythemia and also by frequent occurrence of Monge's disease and pulmonary edema. In contrast to this, very few cases of Monge's disease were reported in the Himalayan population, indicating their better adaptability to hypoxic environments. The high altitude natives of Ladakh may be well adapted to hypoxic environment due to normocythemic hypervolemia.

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