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Pattern of haemoglobin in people of high and low altitude of Khyber Pakhtunkhwa, Pakistan

Babar Ali[1], Anwar Khalid[2], Muhammad Ilyas[3], Muhammad Taj Akbar[4], Tehreem Fatima[1], Amin Jan[5], Shah Faisal[6], Abdullah[4], Ghulam Ishaq[7], Arif Jan[8], Faheem Jan[*9]

[1]*Department of Pathology, Luqman International Hospital, Saidu-Sharif Swat, KPK, Pakistan*

[2]*Department of Chemistry, COMSATS University, Islamabad, Abbottabad Campus, KPK, Pakistan*

[3]*Department of Cardiology, Shaheed Zulfiqar Ali Bhutto University, PIMS, Islamabad, Pakistan*

[4]*Department of Microbiology, Abdul Wali Khan University, Mardan, KPK, Pakistan*

[5]*Department of Pharmacy, Abdul Wali Khan University, Mardan, KPK, Pakistan*

[6]*Department of Biotechnology, Bacha Khan University, Charsadda, KPK, Pakistan*

[7]*Khyber Medical University, Peshawar, KPK, Pakistan*

[8]*Faculty of Veterinary & Animal Sciences, Gomal University D.I. Khan, KPK, Pakistan*

[9]*Programmatic Management of Drug Resistant Tuberculosis Unit, Ayub Teaching Hospital, Abbottabad, KPK, Pakistan*

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Abstract

The main objective of this study was to find out changes in level of haemoglobin concentration associated with high and low altitude areas of Khyber Pakhtunkhwa (KPK). A randomized blood samples were collected from 215 healthy male and female belonging to 20-50 years of age from June 2018 to November 2018. The subjects of the current study were selected from four different district of Khyber Pakhtunkhwa (Abbottabad, Dera Ismail Khan, Peshawar and Swat). Haemoglobin levels of the subjects were analyzed on Nihon Kohden Hematology analyzer (Celltac X MEK-6410K). There was an increase in haemoglobin level, at high altitude namely Abbottabad and Swat as compare to a selected low altitude region i.e. Dera Ismail Khan and Peshawar. We found statistically significant difference in Mean haemoglobin level at high-altitude region (14.25±1.40) and low-altitude region (13.58±1.28). Haemoglobin concentration increases in the blood with elevated altitudes and, thus, at high-altitude areas anemia was less frequent. The mechanism that produces the mean differences showed that altitude may play a vital role in haemoglobin production. This study provides the basis for future research in this area that explores the process of haemoglobin production at both cellular and molecular level. This will focus not only on haemoglobin or red blood cells but also on the tissues they supply.

* **Corresponding Author:** Faheem Jan ✉ drfaheem82@gmail.com

Introduction

Since the beginning of human history, blood has been recognized as a vital force, the essence of life. Blood is a specialized bodily fluid that transports essential components such as oxygen and nutrients to the cells and transports metabolic waste products away from the same cell (http://www.merriam-webster.com/dictionary/blood). It is well documented that heamatological baseline values show a discrepancy in different population and in different geographical areas or altitude (Gilles, 1981). These changes are due to sex, age, altitude (Hawkins, 1954; Dapper *et al.,* 2009), environmental factors and social dissimilarities (Shaper and Lewis, 1971; William, 1981).

A French physician, Viault, first announced an increase in respiratory oxygenating element of blood in Europeans and Andean highlanders. From that point an increase in total quantity of haemoglobin was reported at high altitude by Baker and Little (Baker and Little, 1976); and Monge (Monge, 1954). A similar actuality was shown by Europeans that had been presented to high-elevation stress (Hannon *et al.,* 1969; Beall *et al*., 1998). The haemoglobin level of the blood is generally used as an aid in assessment of the state of health. A sound authentic premise is therefore essential for establishing the pattern of haemoglobin values its relation to sex and age (Hawkins *et al*., 1954). Of the total world's population approximately 12% lives in mountainous areas (Huddleston *et al*., 2003).

Normally, EPO (Erythropoietin) production is mediated by decreased oxygen saturation of haemoglobin, that is, hypoxemia (Krantz, 1991). The effect of altitude is to reduce plasma volume, increase the Hb and Hct and raise the number of circulating red cells with a lowermcV. The magnitude of the Polycythemia depends on the degree of hypoxemia. At an altitude of 2000 m (6500 ft), Hb is c 8–10g/l and Hct is 0.025 higher than at sea level; at 3000m (c 10 000 ft), Hb is c 20g/l and Hct is 0.060 higher and at 4000 m (13000 ft) Hb is 35g/l and Hct is 0.110 higher. Corresponding increases occur at intermediate and at higher altitudes. These increases appear to be the result of both increased erythropoiesis which is secondary to the hypoxic stimulus and the decrease in plasma volume that occurs at high altitudes.

Various physiological changes occur in the human body to compensate for the low partial pressure of oxygen at altitude. In which the increase in the concentration of hemoglobin is very important factor in this process (Windsor and Rodway, 2007). This study was aimed for determination of hemoglobin level in low and high altitude districts of Khyber Pakhtunkhwa.

Materials and methods

Description of study area

The study was carried out in different Districts of low and high altitude of Khyber Pakhtunkhwa (KPK), with collaboration of Pathology Department of Ayub teaching hospital (ATH) Abbottabad, over a period of six months from June 2018 to November 2018. The regions under study contain plain and mountainous areas which include D.I Khan, Peshawar, Abbottabad and Swat district. Of the four selected districts two were low altitude area (D.I Khan, Peshawar) and the remaining two were high altitude area (Abbottabad and Swat). The area plain has an average altitude of 1,000 feet and the mountains of this region attain the average height of 6,000-11,000 feet.

Selection of Subjects

The samples were taken from 215 male and female healthy individuals who were randomly selected from districts of KPK. They were divided into three age groups i.e. young (20-30), middle (31-40) and old (41-50) years.

Inclusion criteria

Both male and female healthy individuals between the ages of 20-50 years.

Exclusion criteria

- Children and pregnant women.
- Individuals with evidence of any type of medical disorder of infectious and non-infectious origin.
- Age less than 18 years and greater than 50 years.
- Individuals used tobacco products, including cigarettes, cigars, snuff etc.

- Individual drank alcoholic beverages.
- Individuals donated blood for the last four months.

Blood Collection and Laboratory Investigation

Following a universal (standard) safety precautions recommended by the Centers for Disease Control and Prevention (CDC); First of all, a tourniquet is wrapped around the upper arm then skin was cleaned thoroughly and sterilized with 70% isopropyl alcohol swab and dried for 30 sec, using 5cc disposable syringe (Becton Dickinson Pak) three (3)mL of blood sample was collected from each subject into tri-potassium ethylenediamine tetra-acetic acid (K_3EDTA) anticoagulant tube. This was well mixed by a mechanical mixer for at least 5 minutes to prevent clotting. The blood samples are counted immediately or within 24 hours after collection. For the determination of Hb Nihon Kohden Hematology analyzer (Celltac X MEK-6410K) was used.

Ethical considerations

The research protocol was approved by the ethical committee of the UIMS College Abbottabad.

Data analysis

The statistical analysis was carried out by simple calculation of arithmetic mean, percentages and oneway ANOVA using SPSS v-20 ®.

Results and discussion

The current study was aimed to analyze the Hb level of healthy population within the two demographical regions of KPK, i.e. high and low altitude. The main objective was achieved by comparing the variation in Hb level amongst both regions. The Hb level was statistically analyzed with gender, age, altitude and location. All the samples were analyzed in Hematology lab, Ayub Teaching Hospital Abbottabad.

There was 101 from low altitude and 114 from high altitude regions (Table 1). A total 215 Healthy individual of the study were distributed in three age groups i.e. young age 20–30 years having 120, Middle age group 31–40 years having 57 and old Age group 41–50 years having 38 number of volunteer individuals (Table 2).

Table 1. Gender wise distribution of Healthy subjects.

Location	Female	Male	Grand Total
High	45	69	114
Low	37	64	101
Total	82	133	215

Table 2. Subjects comprises from high and low altitude with respect to Age groups.

Age groups (year)	High	Low	Total
Young	68	52	120
Middle	29	28	57
Old	17	21	38

The participants were also gender wise distributed and screened for Hb variation according to altitude. The average Hb level is (14.46 ± 1.23g/dl) for male and (13.07 ± 1.17) for female. Comparatively male individuals have greater Hb level than that of female (Table 3). Amongst the four districts, the highest Avg Hb level of 14.53g/dl was observed from Abbottabad which is comprised of 59 respondents, 40 male and 19 female followed by Swat where the Avg.

Hb level was 13.94g/dl, of 55 healthy individuals 29 male and 26 female. On the other hand, Peshawar the low altitude region has 13.64g/dl Avg Hb level with a population of 58 individuals comprised of 39 male and 19 female. While the least Avg Hb level 13.49g/dl was recorded for D.I Khan with a total 43 subjects 25 male and 18 female. The high altitude areas had a high average Hb level as compared to low altitude region as depicted in (Table 4). Overall the highest Hb level (18.1g/dl) was found from individual belong to low altitude region district D.I Khan while the lowest was from Abbottabad (10.9g/dl).

Table 3. Average Hb in High and Low Altitude with Respect to Gender.

Gender	High altitude	Low altitude	Avg Hb ± SD
Male	69	64	14.46 ± 1.23
Female	45	37	13.07 ±1.17
Avg Hb ± SD	14.25±1.40	13.58±1.28	

Table 4. District wise subject distribution with Avg Hb mg/dl level.

District	Male	Female	Total	Avg Hb ± SD
ATD	40	19	59	14.53±1.56
D.I Khan	25	18	43	13.49±1.15
Peshawar	39	19	58	13.64±1.37
Swat	29	26	55	13.94±1.14

Demographical analysis

In this study a total of 215 healthy subject from high and low altitude areas of KPK were randomly selected. From high altitude two districts i.e. Abbottabad and Swat while from low altitude districts Peshawar and D.I Khan were chosen on the basis of their life style, of which the one is well developed and the other one is under-developed. A total of 114 subjects were screened for Hb level comprising 69 male and 45 female from high altitude regions while 101 from low altitude comprising 64 male and 37 female volunteer healthy individuals. Hence the total No of female is 82 and that of male is 133 collectively from high and low altitude areas (Table 5).

Table 5. Gender Wise Distribution of Subject within Both Altitude Areas.

Location	Female	Male	Grand Total
High	45	69	114
Low	37	64	101
Total	82	133	215

The ages of the subjects ranged from 20-50 years that were distributed into three groups. The age group distribution was as follows: young (20-30 years), middle (31-40 years) and old (41-50 years). From total 215 subjects 120 were belonged to young age group in which 68 were from high altitude area and 52 from low altitude area. Furthermore, 57 subjects belonged to middle age group in which 29 from high and 28 from low altitude areas. The last one i.e old age group that consisted of a total 38 subjects, 17 from high and 21 from low altitude areas, respectively (Table 6).

Table 6. Age group Distribution of Subject within Both Altitude Areas.

Age groups (year)	High	Low	Total
Young	68	52	120
Middle	29	28	57
Old	17	21	38

Table No 6 also clearly showed that maximum subjects analyzed in this study for Hb level belongs to young population of the selected regions of high and low altitude areas of KPK. The maximum selection of young population is the sign of selection of healthy and medically fit subjects for this study.

Among the young age group 68 were male and 52 were female. In middle age group 41 male and 16 female were randomly placed, while in old age group only 24 male and 14 female were adjusted by adapting the age based group placement criteria of the study (Table 7).

Table 7. Age group Distribution of Subject from Both Gender.

	Female	Male	Total
Young	52	68	120
Middle	16	41	57
Old	14	24	38
Total	82	133	215

Out of 114 (100%) subjects of high altitude 60% were from young age group, while 25% from middle and 15% from old age group. on the other hand, a total of 101 (100%) subjects belong to low altitude area was comprises as 51%, 28% and 21% of young, middle and old age group respectively. The detail is given in Fig. 1. The association of altitude and haemoglobin concentration has been well established. The partial pressure of oxygen is low at higher altitudes (above 1000 meters) from the sea level, leading to lower oxygen saturation of the blood. Thus, haemoglobin levels increase as an adaptive response to the decreased partial pressure of oxygen and reduced oxygen saturation of blood (Cohen and Haas, 1999; Xing *et al.*, 2009).

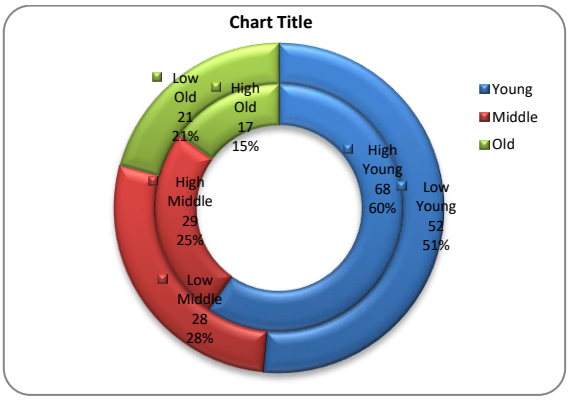

Fig. 1. Subject% from both high and low altitude area.

Mean Hb level

The Hb level is found as highest as 18.1g/dl from D.I Khan and lowest 10.9g/dl from Abbottabad. In male subjects the lowest Hb (11.1g/dl) from Peshawar and highest Hb (18.1g/dl) from D.I Khan was observed with an average of 14.5 ± 1.2g/dl. Both the highest (17g/dl) and lowest (10.9g/dl) Hb values with an average of 13.51 ± 1.2g/dl was obtained from the female respondents of Abbottabad District. These results showed that people living at high attitude areas have an Hb level higher than lower altitude areas. Furthermore, male subjects were found with an average high Hb level than females subjects this is also globally accepted and reported in numerous studies (Table 8). The result of this study revealed that average highest Hb level was found in population of Abbottabad which is 14.53g/dl. Previous study in this regard also showed that altitude may affect the concentration of Hb. Studies conducted by Ramirez *et al.*, in 1999 and Beal (Ramirez *et al.*, 1991; Beall, 2006); in 2006 confirmed that at higher altitudes, i.e. above 1000 meters, haemoglobin levels increase as an adaptive response to hypoxic atmosphere, to the decreased partial pressure of oxygen and decreased oxygen saturation of blood. In our study, Haemoglobin has been increased at high altitude regions i.e. Abbottabad (14.53g/dl) and Swat (13.94g/dl) as compared to low altitude regions of KPK Peshawar for which Haemoglobin Level was (13.64g/dl) followed by D.I Khan (13.49g/dl) which support our results findings that concentrations of haemoglobin are elevated in high-altitude populations. Previous results have confirmed that mean haemoglobin levels were higher in people living at high altitudes, showing a positive association between haemoglobin and altitude (Beall *et al.*, 1998; West, 2006).

Table 8. Gender wise Hb mg/dl, maximum, minimum and Avg values.

Gender	Lowest Hb	Highest Hb	Avg Hb±SD
Male	11.1	18.1	14.5±1.2
Female	10.9	17	13.1±1.2

Conclusion

Haemoglobin concentration is significantly correlated with altitude, increasing with elevated altitude and thus, high altitude residents were less prone to anemia as compared to low altitude residents. A sample of 114 male and female of high altitudes had mean haemoglobin concentrations of 14.25±1.40gm/dl which is higher than those from a sample of 101 male and female from low altitude area with the average Hb 13.58±1.28gm/dl. The mechanism that produces the mean differences showed that altitude may play a vital role in Hb production. This study provides the basis for future research in this area that explores the process of Hb production at both the cellular and molecular level. This will focus not only on Hb or RBCs but also on the tissues they supply. Fascinating research opportunities surely beckon.

Conflict of interest

The authors declare that there is no conflict of interests.

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