

# Hemoglobin cut-off value for apparently healthy adult population at Mekelle city, Northern Ethiopia

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## Abstract

**Background:** Hemoglobin cut-off values are affected by factors such as age, sex, ethnic background, social, nutritional and environmental factors. **Aim:** This study was conducted to determine the hemoglobin cut-off values of healthy adult population at Mekelle city. A cross-sectional study was carried out on 2282 (1195 men and 1087 women) apparently healthy adult individuals whose age were above 15 years. Data were entered into EpiData and analyzed using SPSS version 16 for Windows. **Findings:** The hemoglobin cut-off values of males and females were 13.3-14.4 gm/dl and 12.2-13.1 gm/dl, respectively. **Conclusions:** A large scale study at national level is mandatory to establish the hemoglobin cut-off value of the Ethiopian population for the management of anemia.

**Keywords:** Hemoglobin, Cutoff value, Adult population, Mekelle city, Northern Ethiopia

## Introduction

Anemia is a major public health problem which affects about two billion people worldwide [1-4]. It damages immune mechanisms and is also associated with increased morbidity [4]. Assessments of anemia prevalence in a population assist in determining its magnitude and distribution [3]. It can be based on either hemoglobin (Hb) [1, 3-4]. The Hb cut-off value commonly used to define anemia is based on the normality definition often applied to other clinical laboratory tests and in anthropometry [5].

The Hb values of normal subjects vary in different population groups and in different geographical areas [4, 6-8, 9]. The variations are usually due to age, sex, ethnic background, altitude, nutritional, social, environmental differences and pre-analytical variables [4, 6-7, 9-11]. At birth, the total Hb level is shown to be higher than at any other period of life [4, 7, 11], reflecting fetal adaptation to the oxygen deficient environment of the uterus [11]. The levels of these parameters then decrease during the next few months after birth [4, 7, 11]. This is thought to be due to the sudden decrease in erythropoiesis, or red cell production, as a result of the increased delivery of oxygen to tissues [11]. Then it gradually rises to adult levels by the age of puberty as a result of accelerated growth [5, 7]. Hb levels, on average, decrease with advancing age in men throughout adulthood, but a more modest decline occurs in women after the age of 50 [6, 10]. Also, men have higher Hb concentrations than women [4, 7, 11] because of testosterone, which results in both larger body size and larger erythrocyte mass. Healthy people of African extraction of all age groups have Hb concentrations 5 to 10 g/L below those of whites and this difference is independent of iron deficiency and in some cases hemoglobinopathies and socio-economic factors [11]. Further evidence derives from the observation that normal Caucasians have higher Hb levels than black individuals matched for age and sex [6]. One study in Italy showed that normal males and females of different ages from a northern Italian isolate have significantly higher Hb levels compared to populations of southern Italian isolates [6]. Differences in Hb reference values were also observed in African adult population compared with western adult populations [7]. In addition, Hb increases with an increase of altitude especially when the altitude is above 1000 m above sea level. This is due to an adaptive response to the lower partial pressure of oxygen and reduced oxygen saturation of blood. The compensatory increase in red cell production ensures that sufficient oxygen is supplied to tissues [4, 11]. Therefore, understanding the relationship between Hgb concentration and altitude will have important implications for correctly estimating the prevalence of anemia at high altitudes [4]. Hb levels are not consistently adjusted for elevation, and therefore many anemic patients are left undiagnosed [3]. Hb concentration also increases in smokers because the inhaled carbon monoxide results in increased carboxy-hemoglobin, which has no oxygen-carrying capacity. To compensate, Hb levels increase [11]. In general, every population is diverse from the other and there are multiple factors which can influence normal physiological values for a given set of population making it compulsory to have reference

values of the local population before translating any results into any clinical setting. One must not generalize the use of these tests as one result which can be normal for one group of population, might not be normal for the other living in a totally different area. Furthermore, the effect of race, genetic diversity of populations is well recognized to differ from one area to another [9]. It has, therefore, been stressed that each population must establish its own Hb reference values for use in clinical assessments [4, 7, 11].

Hb reference values have long been well established in many parts of world [7]. However, environmental conditions in Ethiopia are different from other parts of the world in terms of climate and dietary habits of people. Besides, Hb reference values have never been established in Ethiopia, although a few attempts at determining Hb in some populations have been made [12-13]. The values which are currently used in the country are adopted from textbooks which refer mainly to Caucasian subjects [13]. For effective interpretation and distinction in health and disease, it is necessary to establish accurate reference ranges of a population [9]. Therefore, this study was done to establish the Hb cut-off value of adult healthy population at Mekelle city, Northern Ethiopia and this might also serve as Hb normal value for the entire Tigray region.

#### **Patients and Materials**

This cross-sectional study was conducted in Mekelle city; which is located some 780 kilometers north of Addis Ababa with an elevation of 2084 meters above sea level [14]. In an attempt to establish the normal reference values for Hb (hemoglobin), we conducted this investigation and determined the Hb profiles of 2282 (1195 men and 1087 women) healthy adult individuals aged above 15 years. Individuals were grouped according to age and sex, and the ranges for the commonly used Hb were determined. Selection was based on apparently healthy people who fulfilled the following criteria: aged above 15 years, no history of drug usage (including vitamins, iron, and antibiotics), and no recent history of blood loss, not received any blood transfusions in last 12 Months, and volunteered. Additional criteria were included for females as, not being pregnant, not lactating and not menstruating at the time of blood collection. The blood was drawn at in the morning between 8:00 and 11:00 AM. Physical details were recorded and blood samples were drawn by venipuncture. The whole blood was transported at 4°C to Mekelle Hospital, where all the analysis were conducted at hematology department. Measurement of Hgb was carried out within 2 hours of sample collection using Cyanomethemoglobin method [15]. The study was approved by Mekelle University Ethical Review Board (MU-ERB) and participants were informed about the purpose of the study and informed consent was obtained from each participant prior to blood collection. Data were entered into EpiData and analysis was conducted separately for each group using SPSS 16.0 for Windows. Student's t-test was used to make comparisons between any two groups.  $P < 0.05$  was considered statistically significant.

#### **Results**

This study analyzed the hemoglobin (Hb) profile of 2282 (1195 men and 1087 women) apparently healthy adult individuals aged above 15 years that were randomly selected from a community setting. The mean Hb values of men and women were 13.8 gm/dl and 12.6 gm/dl, respectively (Table 1). Hb level was lowest between the age of 15-24 years in both males and females. It was highest between the age of 35-44 in males and 45-54 in females (figure 1).

Table 1: Distribution mean value with 95% CI and median with 95 percentile range of hemoglobin (Hb) for apparently healthy adult population in Mekelle city, Northern Ethiopia

Age group	Sex	Hb (g/dl)		
		Mean [95% CI]	Median [95 percentile range]	p-value
15-24	M (n=200)	13.1[12.3-13.9]	13.5[7.2-16.8]	0.045
	F (n=205)	12.4[11.9-13.4]	13.2[7.5-16.0]	
25-34	M (n=180)	14.0[13.6-14.5]	14.8[9.0-18.2]	0.013
	F (n=214)	12.6[12.3-13.0]	13.3[7.4-16.1]	
35-44	M (n=225)	14.4[13.6-15.2]	14.3[9.2-18.0]	0.035
	F (n=260)	12.2[12.1-12.4]	12.5[7.8-15.2]	
45-54	M (n=190)	13.6[13.2-14.1]	13.5[7.8-15.9]	0.032
	F (n=201)	12.9[12.4-13.5]	12.5[8.5-15.4]	
55+	M (n=400)	13.8[13.8-14.2]	13.5[8.0-15.8]	0.021
	F (n=207)	12.8[12.5-13.1]	12.4[9.0-16.5]	
Total	M(n=1195)	13.8[13.3-14.4]	13.9[8.5-17.2]	0.017
	F (n=1087)	12.6[12.2-13.1]	12.7[7.9-15.0]	

Hb=Hemoglobin, M=Male, F= Female, n= Number, g/dl= gram/deciliter, p-value= significance difference of Hb between gender

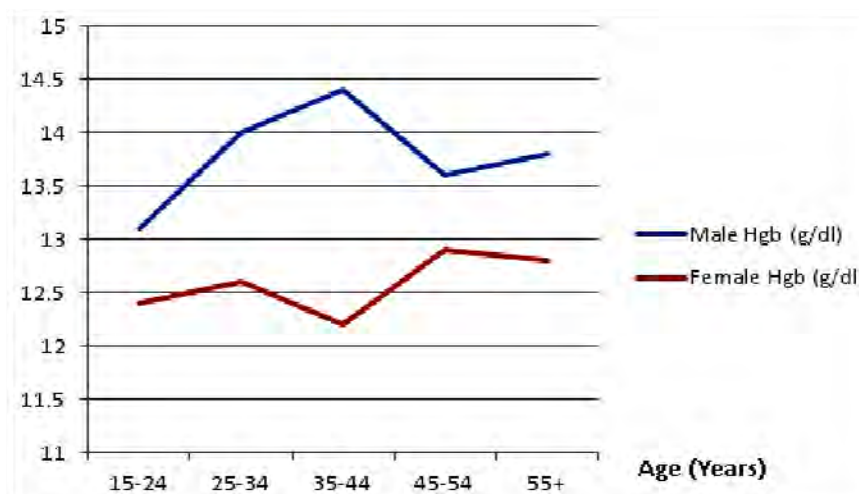


Figure 1. Mean hemoglobin (Hb) value for healthy adult population of Mekelle city, Northern Ethiopia

### Discussion

Reference ranges are necessary in hematology to compare observed values and to provide meaningful information. Therefore, it is important to have reference values of the local population before translating any results into any clinical setting [7]. Many studies all over the world showed variability of hemoglobin (Hb) reference values [12]. Although few studies tried to show Hb reference values on segments of Ethiopian population, the present study is more comprehensive in terms of the quantity and the size of the population studied.

In this study, the mean Hb values at all age strata were significantly higher ( $p < 0.05$ ) for men than women. Such difference by sex is in line with the findings of other previous studies from different parts of the world [4, 6-7, 12-13, 15-17]. This may be because of the testosterone in males which results in both larger body size and larger erythrocyte mass [11]. Besides, slight differences of mean Hb values by age groups within same sex were observed with no specific pattern. This finding more or less similar to the study conducted in Gigel Gibe [12]. The mean Hb values for both gender in the present study was similar to study in Uganda [18]. However, it was

higher than the findings from Pakistan [7]. However; it is lower than the findings of studies in Italy [6], Ethiopia [13], for both gender, and Malaysia [9] for males. However, mean Hb value for females in the present study was higher than similar study in Malaysia [9]. Besides, the male mean Hb value in this study was lower than similar studies conducted in Ethiopia [13], Central African Republic [16], and Ghana [17]. The difference values Hb in different parts of the world could be due to many possibilities: a bias in selection of the study subjects, differences in ethnic background, altitude, nutritional, social, environmental and pre-analytical variables [4, 6-7, 9-11].

The present study showed (figure 1) pronounced (elevated) Hgb in males vs decreased Hgb in females in the ages 35-44. Furthermore, beyond the age of 55 males reach a plateau in Hgb levels, while in females Hgb is still decreasing. This could be due to a bias in selection of the study subjects [7], and or decreased physical activity of women than men within these age groups [19, 20].

### Conclusion

In conclusion, this study has established the hemoglobin cut-off value for apparently healthy adult population at Mekelle city. Similar large scale studies at national level is mandatory to establish the hemoglobin cut-off value for the Ethiopian population for the management of anemia.

### Abbreviations

Hb: hemoglobin, MU-ERB: Mekelle University Ethical Review Board

### Competing interests

The authors declare no potential conflict of interest. The sponsor had no role in the design, implementation, or publication of the study.

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### References

- [1] Xing Y, Yan H, Dang S, Zhuoma B, Zhou X, Wang D: Hemoglobin levels and anemia evaluation during pregnancy in the highlands of Tibet: a hospital-based study. *BMC public health* 2009,9:336-43.
- [2] Karaoglu L, Pehlivan E, Egri M, Deprem C, Gunes G, Genc MF, et al: The prevalence of nutritional anemia in pregnancy in an east Anatolian province, Turkey. *BMC Public Health* 2010,10:329-41.
- [3] Laflamme EM: Maternal Hemoglobin Concentration and Pregnancy Outcome: A Study of the Effects of Elevation in El Alto, Bolivia. *MJM* 2010,13:47-55.
- [4] El-Hazmi MAF, Warsy AS: Normal reference values for hematological parameters, red cell indices, Hgb A2 and Hgb F from early childhood through adolescence in Saudis. *Ann Saudi Med* 2001,21:165-9.
- [5] Yip R: Significance of an abnormally low or high hemoglobin concentration during pregnancy: special consideration of iron nutrition. *Am J Clin Nut* 2000, 72:272S-9S.
- [6] Sala C, Ciullo M, Lanzara C, Nutile T, Bione S, Massacane R, et al: Variation of hemoglobin levels in normal Italian populations from genetic isolates. *Haematologica* 2008, 93:1372-1375.
- [7] Usman K, Syed ZA, Rao AA: Reference range values of haematological parameters in healthy pakistani adults. *Pak J Physiol* 2007, 3:19-22.
- [8] WHO: Haemoglobin concentrations for the diagnosis of anemia and assessment of severity [Internet]. Geneva: VMNIS; [cited 2013 Jul 29]. Available from: <http://www.who.int/vmnis/indicators/haemoglobin.pdf>.
- [9] Roshan TM, Rosline H, Ahmed SA, Rapiaah M, Zaidah AW, Khattak MN: Hematological reference values of healthy Malaysian population. *Int J Lab Hematol* 2009,31:505-12.
- [10] Patel KV: Variability and heritability of hemoglobin concentration: an opportunity to improve understanding of anemia in older adults. *Haematologica* 2008 93:1281-1283.
- [11] Nestel P: Adjusting Hemoglobin Values in Program Surveys [Internet]. Washington: INACG; [cited 2013 Mar 23]. Available from: [http://pdf.usaid.gov/pdf\\_docs/PNACQ927.pdf](http://pdf.usaid.gov/pdf_docs/PNACQ927.pdf).
- [12] Haileamlak A, Muluneh AT, Alemseged F, Tessema F, Woldemichael K, Asefa M, et al: Hematoimmunological profile at Gilgel Gibe field Research Center, Southwest Ethiopia. *Ethiop J Health Sci* 2012, 22:39-49.
- [13] Tsegaye A, Messele T, Tilahun T, Hailu E, Sahlu T, Doorly R, et al: Immunohematological Reference Ranges for Adult Ethiopians. *Clin Diagn Lab Immunol* 1999,6:410-4.
- [14] Mekellecity.com: About Mekelle [Internet]. Mekelle: ARHONET; [cited 2013 Feb 10]. Available from: <http://www.mekellecity.com.asp>.
- [15] Neufeld L, García-Guerra A, Sánchez-Francia D, Newton-Sánchez O, Ramírez-Villalobos MD, Rivera-Dommarco J: Hemoglobin measured by Hemocue and a reference method in venous and capillary blood: A validation study. *Salud pública de México* 2002, 44:219-27.
- [16] Menard D, Mandeng MJ, Tothy MB, Kelembho EK, Gresenguet G, Talarmin A: Immunohematological Reference Ranges for Adults from the Central African Republic. *Clin Diagn Lab Immunol* 2003,10:443-5.
- [17] Koram KA, Addae MM, Ocran JC, Adu-Amankwah S, Rogers WO, Nkrumah FK: Population Based Reference Intervals for Common Blood Haematological and Biochemical Parameters in the Akuapem North District. *Ghana Med J* 2007, 41:160-6.
- [18] Lugada ES, Mermin J, Kaharuzza F, Ulvestad E, Were W, Langeland N, et al: Population-based hematologic and immunologic reference values for a healthy Ugandan population. *Clin Diagn Lab immunol* 2004,11:29-34.
- [19] Al-Fathy MYA: Physical Activity and Hemoglobin Level among Married Women during Childbearing Age in Mosul. *Tikrit Medical Journal* 2012,18:81-88.
- [20] Choudhary S, Rajnee, Binawara BK: Effect of exercise on serum iron, blood haemoglobin and cardiac efficiency. *J Postgrad Med Inst* 2012,26:13-6.