Addis Ababa University

College of Health Sciences

Department of Internal Medicine

Title: Peripheral oxygen saturation measured using pulse oximeter among healthy adults at moderate to high altitude city of Addis Ababa, Ethiopia.

Principal investigator: Bethelhem Berhanu, MD, Internal Medicine Resident

Advisors:

1. **Wondwossen Amogne, MD, PhD, Associate Professor of Medicine and Infectious Diseases specialist**
2. **Tewodros Haile, MD, Associate Professor of Medicine and pulmonary and critical care specialist**

A manuscript submitted to Addis Ababa University, College of Health Sciences, School of Medicine, Department of Internal Medicine in preparation for partial fulfillment of the requirement for a Specialty certificate in Internal Medicine.

December,2021

Title: Peripheral oxygen saturation measured using pulse oximeter among healthy adults at moderate to high altitude city of Addis Ababa, Ethiopia

Principal Investigator: Dr. Bethelhem Berhanu (MD, 3rd year internal medicine resident)
Email:betiberhan@yahoo.com, Mobile: +251912138528

Advisors: Wondwossen Amogne, MD, PhD, Associate Professor of Medicine and Infectious Diseases specialist

Tewodros Haile, MD, Associate Professor of Medicine and pulmonary and critical care specialist
Signature ____________________ Date ____________________

Department head: Dr Abdurezak Ahmed (Consultant Internist and Endocrinologist, Associate professor of Medicine)
Signature ____________________ Date ____________________

Declaration

I Bethelhem Berhanu, declare that this thesis is my original work and has not been submitted elsewhere. I also declare that a complete list of references is provided indicating all the sources of information quoted or cited.

Signature ____________________ Date ____________________

Acknowledgement

I want to express my sincere gratitude to the Department of Internal Medicine, College of Health Sciences, Addis Ababa University, for facilitating the opportunity and providing the funding to conduct this research.

My utmost appreciation goes to my advisors Dr. Wondwossen Amogne and Dr. Tewodros Haile for their guidance and support in conducting my research. I am also grateful to Dr. Dawit Kebede and Dr. Amir Sultan for their invaluable input during proposal development and write up of the manuscript.

I am also grateful to all my family and friends for their unconditional support and encouragement. Above all, I would like to thank God who helped me through all this.

Table of Contents

List of Tables

List of Figures

Abbreviations

SaO_2	Arterial oxygen saturation
SpO_2	Peripheral oxygen saturation
O_2	Oxygen
Msc	Microsoft
RR	Respiratory rate
PR	Pulse rate
BP	blood pressure
SBP	systolic blood pressure
DBP	diastolic blood pressure
BMI	Body mass index
Hgb	Hemoglobin
FEV_1	Forced expiratory volume at 1 second
COPD	Chronic obstructive pulmonary disease
M	Meters
Kg	kilogram
g/dL	gram per deciliter
mmHg	milli meter mercury
HC	health center

Summary

Background: At high altitude, human body undergoes some changes as part of acclimatization and adaptation for exposure to inadequacy of oxygen due to reduction on barometric pressure of oxygen. Inadequacy of oxygen might lead to hypoxemia. The other well-known component of high altitude physiological adaptation is change in hemoglobin concentration. It is very important to know the changes in peripheral oxygen and hemoglobin (hgb) values of healthy adults living in moderately to high altitude areas such as Addis Ababa so that it helps to determine target values during disease states. However, such data are lacking for residents of Addis Ababa.

Objective: The study was conducted to assess the profile of distribution of peripheral oxygen saturation measured with pulse oximeter among healthy adult population in the moderate to high altitude city of Addis Ababa. We also determined the hemoglobin concentration level of the participants to see if there is hematologic effect of altitude elevation on the permanent residents of Addis Ababa. In addition, other predictors of oxygen saturation in residents of Addis Ababa were assessed.

Methods: A cross-sectional study was conducted between the dates of July 30, 2021 and November 30, 2021 on permanent and active apparently healthy residents of Addis Ababa. Data was collected via structured questionnaire as well as direct measurement of weight, height, RR, PR, BP, Hgb level and spo_2 with appropriate gadgets. The collected data was checked for completeness and consistency and was entered to Excel. SPSS version 26.0 was used for analysis**.** Mean, median, standard deviation and variance were calculated. The Chi-square test was used to identify determinant variables. A significant level of $p < 0.05$ was taken to conclude that the variable has a statistically significant impact on the value of oxygen saturation.

Result A total of 296 participants were enrolled among which 108 (36.5%) of the participants were male while 188 (63.5%) of the participants were female. The median age of the participants was 27 years, IQR (23,33). Larger proportion of study participants fall under healthy BMI category,63.2% of the study population. The mean SpO_2 (±SD) of the study population was 95.6 %(±1.61) with mean SpO_2 value of male participants being 95.61% (±1.54) and 95.63 (±1.64) for female participants. Over two-third of the participants, 68.5% of male participants and 69.1% of female participants had saturation value of ≥ 95%. The mean Hgb (±SD) was found to be 15.59 (±1.58) g/dl , 16.53 (±1.46) g/dl for males and 15.05 (±1.3) g/dl for females. There was no significant association between category of spo_2 versus sex (p=.910), BMI(p=.580), female hgb category (p=.610) and male hemoglobin category (p=.861) individually. Fisher's exact test done between age categories and spO_2 categories, showed statistically significant association between the two variables (two-tailed p = .000) with lesser participants achieving spo_2 of 95% and above as their age increases.

Conclusion Majority of the sample population had spo_2 with in the normal range proposed by WHO. In addition, the hgb profile also shows the majority of the participants had hgb value within the suggested normal cut offs. Thus, we share the previous thought of conclusion made on Ethiopians having yet undetermined adaptation mechanism for exposure to high altitude as there is no phenotypic effect on their spo_2 or Hgb. Consequently, we can follow the already put forward cut off value for normal Spo_2 as well as hypoxia when making medical decisions in treating our patients.

Key words Moderate altitude, oxygen saturation, hemoglobin, Addis Ababa

Introduction

Background

Oxygen is a paramount natural resource on which survival of all living things depend on. It is the key element of aerobic respiration for the production of energy to sustain life. The amount of oxygen found in the human body can be measured and interpreted as saturation of hemoglobin binding sites in the blood stream with oxygen. [1]

There are various ways to measure whether the level of oxygen in the human body is enough to avoid the risk of tissues not getting adequate oxygen to meet their metabolic necessities. We can measure arterial oxygen saturation directly from arterial blood and quantify the percent of oxyhemoglobin in the blood using lab tests. On the other hand, we can measure peripheral oxygen saturation, which is a measure of the percentage of saturated hemoglobin in the capillary bed non-invasively using pulse oximeter. [1]

Hypoxemia is the presence of low partial oxygen tension in which the supply of oxygen is not being adequate either to a specific tissue or the body as a whole. There is different opinion on the cutoff point of SpO_2 level below which tissue hypoxia ensues. But generally, Spo_2 level 95% to 100% are considered normal, while SpO_2 lower than 90 is considered hypoxemia. [4,1]

Hypoxemia can be caused by hypoventilation, ventilation-perfusion mismatch, right-to-left shunt, diffusion impairment, reduced inspired oxygen tension, genetic disorders of hemoglobin oxygen affinity, and other hemoglobin issues which affect oxygen delivery. Altitude which brings reduced oxygen tension is one factor that could cause hypoxemia and will be the area of study for this proposal. As the altitude increases there is reduction in barometric pressure so does partial pressure of inspired oxygen along with it, subsequently impairing oxygen diffusion by decreasing the oxygen gradient from the alveolus to the artery. This effect is significant at altitudes of 1500m and above which is considered moderate altitude .[4] While altitude from 1524-2438m above sea level is considered moderate altitude, high altitude is delignated from 2438-4267m above sea level. Whereas very high altitude and extreme high altitude are put as 4267-5486 m and 5486-8847 m above sea level respectively.[5]

The human body undergoes physiologic changes to cope with this hypobaric hypoxia by acclimatization during acute exposure and adaptation with chronic exposure to high altitudes.[6,1] The term adaptation is used to describe features of behavior, structure and function which are useful and are enabling the survival of human beings in a certain environment. These features could have genetic origin or they could be developmental or physiological processes only. Genetic adaptation is a heritable feature produced as a result of natural selection or other force of evolution and it alters allele frequencies over time. Developmental adaptation on the other hand is an irreversible acquired feature that confer survival benefit for populations exposed to an environmental stressor though out their life time. [7]

The other well-known component of high altitude physiological adaptation is change in hemoglobin concentration. Hypoxemia stimulate an increased production of erythropoietin from specialized renal cells thus causing increase in hemoglobin concentration. This change takes place starting few hours after exposure to high attitude and continue up-to four weeks. This change will help to balance the decrement in oxygen saturation and restore the availability of oxygen in the blood to comparable levels to that of see level.[6] As seen from different studies the presence of increased hemoglobin concentration was not uniform across different population living in high altitude. while it is seen in some populations, it might be altogether absent in other populations due to alternate mechanisms the population developed to tackle the hypoxemia of high altitude environment. [19.20.21,22]

Ethiopia is a country found in east Africa, and its geography is composed of a complex of mountains and plateaus which are separated by the great rift valley. Its highest plateaus vary between 1,290 to 3,000 m above sea level. Addis Ababa is the capital city of Ethiopia and is the third highest capital in the world.[8,9] The city is located in the foothills of Mount Entoto with an average elevation of 2600 meters above mean sea level. The altitude of the city ranges from the highest elevation of 3041 meters which is the peak of Mount Entoto to the lowest part found at Akaki plain which is 2051 meters above mean sea level.[10,11] The range of elevation variation of Addis Ababa is within the category of moderate to high elevation above sea level and its average elevation lies among high altitude elevation category. The city has 11 sub cities with variable average elevation. With average elevation highest to lowest the 11 subcities with their corresponding elevation are, Gulele (2688m), Yeka(2471m), Arada (2436m), Kolfe keraniyo(2417m), Lemi Kura (2362m), Kirkos(2352m), Lideta (2327), Nifas silk lafto (2224m), and Akaki kality(2125m).[12,13]

Statement of the Problem

Oxygen saturation should decline with ascent in altitude due to the decrement in barometric pressure; subsequently affecting the oxygen that reaches to the tissues. There are normal oxygen saturation reference ranges put forward for different altitudes based on the data compiled from many studies conducted at different elevations. [14] The presence of clear cut off values for normal and abnormal oxygen saturation will have paramount importance as they may help in clinical decision making for the supplementation of oxygen in anticipation of hypoxemia.[10] Furthermore, this issue is timely and sensitive in the age of COVID-19 pandemic whereby oxygen supplementation is the core management principle of the disease.

While the previously mentioned reference ranges of normal oxygen saturation which correspond to altitude are helpful; there are no reference ranges for people who live in moderate altitude areas. Addis Ababa being categorized among cities with moderate to high elevation, it never had previous population wide studies to determine saturation reference range applicable to its residents.

This study proposed to measure oxygen saturation of permanent residents of Addis Ababa using pulse oximeter who may be affected by high altitude adaptation with possible decreased set point of normal SpO_2. The study will also try to investigate the presence of hemoglobin level increment as a result of the moderate to high altitude of the city and asses the association of other predictors of oxygen saturation. The study will focus only on healthy residents who are born in Addis Ababa and stayed all their life in Addis Ababa to develop physiologically significant adaptation to the moderate to high elevation of the city.

Significance of the study

This study will be a guide for practicing evidence-based decision making for managing patients with hypoxia by providing insight into the normal SpO_2 of the general population of Addis Ababa. Thus, oxygen administration will be guided by the population specific finding of normal SpO_2 helping to fine tune the threshold to supplement oxygen for patients with hypoxemia.

Literature Review

Pulse oximeter

Pulse oximetry uses spectrophotometric method by illuminating the skin and measuring changes in light absorption of oxygenated (oxyhemoglobin) and deoxygenated blood (reduced hemoglobin) utilizing two separate light wavelengths: 660 nm (ruddy) and 940 nm (infrared). The ratio of absorbance at these wavelengths is calculated and compared with previously calibrated direct measurements of arterial oxygen saturation (SaO_2) to establish an estimated measure of peripheral oxygen saturation (SpO_2). The waveform, which is available on most pulse oximeters, helps clinicians in distinguishing an artifact from genuine signal. [2,3]

Pulse oximeter is currently being used universally in different clinical setting to monitor patient's oxygenation. There is a waveform seen on most pulse oximeters to guide clinicians in differentiating artifacts from true signal contributing to accurate measurement. In one review of pulse oximetry in critically ill patients whose SpO_2 value was 90% and above, there was less than 2% mean difference between arterial oxygen measurements and peripheral oxygen saturation measurements. Meanwhile this difference increased when patients SpO_2 was lower than 90%[3]. In another study done on patients who were staying in intensive care unit concluded changes in SpO_2 do not equate reliably to the SaO_2 changes in critically ill patients.[15] In an older meta-analysis the findings for the difference between arterial oxygen measurements and peripheral oxygen saturation measurements were similar to the previously mentioned study. This paper added when comparing ear and finger probes, accuracy was better from finger probes. [16]

Using pulse oximeters have limitations which may lead to error in measuring saturation readings. Conventional pulse oximeter only distinguishes reduced hemoglobin and oxyhemoglobin and assumes absence of dyshemoglobinemias. According to studies the presence of high carboxyhemoglobin (COHb) and methemoglobin (MetHb) could affect the accuracy of the SpO_2 recording. In addition it is also found that intravenous dyes, low perfusion pressure from low cardiac output, vasoconstriction, and hypothermia; patients with sickle cell anemia and pigmented nails could lead to inaccurate readings. [3] . one recent study was done on patients in intensive care units at 178 hospitals and inpatients who were receiving supplemental oxygen at the university of Michigan Hospital. The study tried to asses occult hypoxemia (i.e., an arterial oxygen saturation of <88% despite an oxygen saturation of 92 to 96% on pulse oximetry) among patients who identified their race as Black or White by analyzing paired pulse oximetry recordings with arterial oxygen saturation values. The result proved that black patients had more frequent occult hypoxemia which was three times more when compared to the white patients, which was not picked by the pulse oximeter. The study suggested reliance on pulse oximeter might put the black population at risk of hypoxemia.[17]

Effect of altitude on peripheral oxygen saturation and hemoglobin

Due to physiological response to increased barometric pressure it has already been established a difference in altitude lead to change in saturation level of people residing in that environment. Even moderate elevation in saturation to the level of 725m has been shown to have significant difference in peripheral saturation when compared to near seal level. Nadir SpO_2 was 95% at moderate altitude while those at sea level had 97% at rest (98.53 ± 0.52) compared to moderate altitude (98.11 ± 0.8; $p < 0.01$). However the paper deduced the clinical significance of this difference is probably minimal, in terms of human health. [4] In a study which tried to measure high altitude adaptation states Andeans, Tibetans, and, less often, Ethiopians possess adaptation traits for O_2 transport which varies from those of only acclimatized newcomers, which indirectly implies the presence of genetic adaptation to high altitude. Short term exposure led to acclimatization which is developmental and genetic changes after long term exposure to high altitude show temporal gradient and all help in influencing O_2 content. Leading to the conclusion that adaptation improved O_2 delivery and metabolism.[18]

After initial exposure to a high altitude area physiological response of acclimatization involves two major changes; ventilatory and hematologic responses. Ventilatory responses emanate as a response to hypoxia which is sensed by peripheral chemoreceptors like the carotid bodies and signals the body to increase ventilation within seconds to minutes. This hyperventilatory response in turn leads to a decrement in partial pressure of carbon dioxide and bring respiratory alkalosis. This will lead to higher alveolar ventilation and partially offset the decreased arterial oxygen. This process doesn't bring a sea level physiological state and arterial oxygen saturation remain low. There is also increased erythropoietin level leading to increase in hemoglobin level which in turn improve the oxygen carrying capacity of the blood.[7]

Many studies done on population of high altitude especially Andean, Tibetan and Ethiopian highland residents has concluded that high altitude adaptation take place by specific genetic alteration. However, it was found this different population adapt to the same environmental stress differently, with convergent evolution affecting different genes from the same pathway. In 2002 the comparison of three regions in different continents has shown 3 different phenotypes of adaptation in Andean, Tibetan and Ethiopian highland dwellers. The Andean high altitude population was found to have high hemoglobin concentration relative to Tibetan and Ethiopian high altitude dwellers. The Tibetan high-altitude population on the other hand has reduced oxygen saturation of arterial hemoglobin in comparison to their Ethiopian and Andean counterparts. There was no significant change in hemoglobin and oxygen saturation in Semen plateau inhabitants of Ethiopia compared to lowland inhabitants. When compared to the Andean population, the Tibetan were found to have high hypoxic ventilatory response subsequently increasing the resting minute ventilation. This explains the reason behind increased red cell production in Andean population which is to compensate for limitation in delivery of oxygen due to blunted hypoxic ventilatory response. On the contrary it is deduced Ethiopians must have improved oxygen delivery to the circulation and an increase in oxygen affinity of red blood cells as a result of natural selection while the genetic basis of such adaptation still needs to be explored further. [19,20,21,22,]

The increased hemoglobin concentration in high altitude inhabitants was also studied on different population. In addition to the studies mentioned above another study done on workers commuting between and altitude of 3,800 m (2-week working shift) and lowland below 1,700 m (2 weeks of holiday). hemoglobin levels of 266 healthy males with exposure to intermittent high altitude ranging 0 to 21 years were included in this study. After excluding comorbidities that might affect the hemoglobin values the result was, hemoglobin concentration increased 0.068 g/dL [95% CI: 0.037 to 0.099, $p < 0.001$] for every year of intermittent high altitude exposure. Even after accounting for confounding variables there was a statistically significant hemoglobin concentration increase.[23] The presence of hemoglobin concentration variation across population was also studied by comparing hemoglobin level for Tibetans and Bolivian Aymara populations who are a native residents at 3800 – 4065 meters. The result suggested both Tibetan male and female had significantly lower hemoglobin concertation when compared with their Aymara counterparts. The Tibetan male had hemoglobin concentration of 15.6g/dl and the female had 14.2 g /dl while the Aymara males had a hemoglobin of 19.2 g/dl and the female had 17.8 g/dl.[24]

Predictors of oxygen saturation

In addition to altitude and hemoglobin value, which are the main determinants of oxygen saturation level, different studies have found additional predictors of oxygen saturation levels. From the data found from PLATINO study done in 2004 which aimed at measuring COPD prevalence in Latin America's major cities, in adults above age of 40, also found that additional predictive factors for hypoxemia. This includes age, body mass index and a low FEV_1 [25]. Another cross sectional study done to asses the distribution of low pulse oximetry values in general adult population and their association with certain predictors found out that the strongest predictors with significant association with resting abnormal saturation level ($SpO2 \leq 95\%$) increased body mass index (BMI) (OR of BMI ≥35 = 6.2, CI(4.2,9.2)), and reduced forced expiratory volume in 1 s (FEV_1) % predicted (OR of FEV_1% predicted <50 = 4.1, CI(2.5, 6.7)), followed by increased age, male gender, and smoking ($p < 0.001$). Other significant predictors were elevated C-reactive protein (CRP) ($p < 0.005$), former smoking, breathlessness and elevated hemoglobin ($p < 0.01$). The frequency of $SpO2 \leq 95\%$ was also found to be significantly increased by increasing levels of BMI. In addition heart rate > 100 beats/min and hemoglobin level exceeding upper limit of normal were associated with high frequency of $SpO2 \leq 95\%$ (19.4%) and (19.8%) respectively. [26]

There are not many studies done on the permanent residents of Addis Ababa to delineate the normal value of their oxygen saturation which might have been altered considering the moderate to high elevation of the city. An old study based on a field survey of 236 Ethiopian native residents at 3,530 m, 14–86 years of age found an average oxygen saturation of hemoglobin of 95.3%.[19] A more recent study was done on healthy under 5 children who are permanent residents of Addis Ababa, Ethiopia using pulse oximetry and they reported on mean SpO_2 of 93.59% (95% CI 93.06%, 94.11%) with a median of 94.67%. the mean Spo2 was 93.5%, with median of 94% setting a possible reference value for children with similar altitude.[10]

Objectives

General Objective

The general objective of the study is to determine the profile of peripheral oxygen saturation value, hemoglobin concentration and its predictos in healthy adult permanent residents of Addis Ababa, Ethiopia in 2021 using pulse oximeter.

Specific objectives

- To asses pattern of oxygen saturation in healthy adult permanent residents of Addis Ababa living in different sub-cities.
- To identify pattern of hemoglobin concentration of permanent residents of Addis Ababa
- To identify predictors of oxygen saturation in permanent residents of Addis Ababa.

Methods and Materials

Study area and period

The study was conducted among healthy permanent residents of Addis Ababa, the capital city of Ethiopia which is has an altitude of 2600 meters above sea level. The study participants were recruited from healthy attendants, students, and employees of TASH and Teklehaimanot health center. The study was conducted from July 30, 2021- November 30,2021.

Study design

A cross sectional study design was used to determine oxygen saturation values in healthy residents of Addis Ababa using pulse oximeter.

Source and study population

Source population

All healthy adult permanent residents of Addis Ababa.

Study population

Permanent residents of Addis Ababa who are actively functioning in the community and fulfill the eligibility criteria and gave consent were included in the study.

Eligibility criteria

Inclusion criteria

All residents of Addis Ababa who fulfill the following eligibility criteria

- Men or women aged ≥18 years old
- Permanent resident of Addis Ababa
- Permanent residents of Addis Ababa who have accessible recent hemoglobin determination over the past 3 months or who are wiling to give blood sample for hemoglobin analysis.

Exclusion criteria

- Pregnant women
- Individuals who have any known cardiac or respiratory illness
- Previous Pulmonary tuberculosis treatment
- Previous severe COVID-19 infection
- Recent respiratory symptoms or infections
- individual who has cough or shortness of breath
- Current or ex-smoker
- Individuals with history of exposure to domestic or occupational dust and fumes
- Significant nail painting
- Individuals with signs and symptoms of Anemia

Study variables

The independent variables in this study are:

- Age
- Sex
- Sub city
- Occupation
- BP
- RR
- PR
- BMI
- Hgb
- Duration of stay out of Addis Ababa
- Place of stay out of Addis Ababa

The dependent variable in this study is:

- Spo2

Operational Definitions

Permanent resident of Addis Ababa – An individual who was born and raised in Addis Ababa and lived all their life in the city.

Healthy residents- individuals with no known(self-reportable) chronic cardio respiratory condition that could affect his oxygen saturation and is actively functioning in the community

Signs and symptoms of Anemia – complaint of easy fatiguability, tinnitus, light headedness or has palmar and conjunctival pallor.

Respiratory Symptoms - common symptoms of upper and lower respiratory tract infection like cough, nasal congestion, nasal discharge, shortness of breath and pleuritic chest pain

Significant nail painting- any nail painting or nail polishing over the nails of the fingers on which pulse oximeter is going to be put on.

Sample size determination and Sampling technique

Sample size was calculated using

$$\mathbf{S = (z^2 (d(1 - d))/ e^2) / 1 + (z^2 (d(1 - d)) / e^2)}$$

S *= sample size |* ***P*** *= population size |* ***z*** *= z-score |* ***e*** *= margin of error |* ***d*** *= standard deviation*

We used population size of 5,005,524, Z score of 1.96 for 95% confidence interval, 5% margin of error and standard deviation used is 0.5. The resulting sample size is **385.**

A convenience sampling method was used to achieve the sample size calculated.

Data collection procedures

Individuals who fulfilled the eligibility criteria and who gave consent for the data collection were enrolled at the data collection sites of TASH and Teklehaimanot HC after they were approached during their visit to the aforementioned health facilities to get medical checkup documentation for employment or while attending patients. Standardized data collection questionnaires were used to collect some components of the study variables including basic sociodemographic data. Weight and height were measured using Tefal digital weight scale and standard tape meter respectively. Respiratory rate of the individuals was counted manually while pulse rate and oxygen saturation were recorded using portable pulse oximeters. Accurate and Jumper pulse oximeter brands were used. The hemoglobin level was retrieved from the individuals' health record for those with recent hemoglobin determination at Teklehaimanot HC. All the retrieved hemoglobin values were analyzed using Hemocue hgb analyzer. The rest of the participant’s hemoglobin was analyzed on the site of data collection using Mission point of care hgb analysis machine by taking a drop of blood from finger prick. The peripheral oxygen saturation of the participants was measured 3 times over a period of 10 minutes using pulse oximeter at 0,5 and 10 minutes. The visibility of normal signal waveform on the pulse oximeter were checked before recording of every saturation data. At the end of 10 minute the blood pressure of the individual was measured using manual sphygmomanometer and stethoscope while the participant was siting, with the left arm comfortably resting at the heart level. The aforementioned data were collected by trained data collectors and the principal investigator using the MSc Excel template.

Data quality and management

The collected data was checked for completeness and consistency on each day of data collection. Supervision and monitoring were made every day by the principal investigator.

Data processing and analysis

After data collection, the response of the survey was entered on MSc Excel, cleaned, coded and exported to SPSS version 26.0 for analysis using descriptive statistics. Mean, median, standard deviation and variance were calculated. The lower limit was computed from the mean, standard deviation and variance. The Chi-square test was used to identify determinant variables. A significant level of $p < 0.05$ was taken to conclude that the variable has a statistically significant impact on the value of oxygen saturation.

Ethical consideration

Informed oral consent was given from participants of the study. Ethical clearance was obtained from the Research and Ethics Committee of the department of internal medicine. College of Health Sciences, AAU. The safety and privacy of subjects was protected by using a code to identify them for data collection and analysis process.

Plan for dissemination of findings

The finding of this study will be submitted to Addis Ababa University, College of health sciences. It will also be submitted to Ministry of Health of Federal Democratic Republic of Ethiopia. It will be presented on different national and international seminars and workshops. Finally, it will be published on peer reviewed journals.

Results

Demographic characteristics of study participants

Among the calculated sample size of 385, a total of 303 participants were included in this study. Attaining sample size was not possible due to inaccessibility of additional strips for the Mission point of care hgb analyzer.

After looking at the data of the 303 participants 5 participants were excluded from the analysis due to the presence of anemia which would affect out research outcome. Thus, a total of 296 participants were enrolled among which 188 (63.5%) of the participants were female while 108 (36.5%) of the participants were male. The age of participants ranged from 18 years up to 83 years with the median age of 27 years, IQR (23,33), with the most frequent age category being 18-24 years. Majority of the participants were from Lideta sub city (28%) with participants from all the 11 sub cities of Addis Ababa were included in the study. Most of the participants were government employees (35.1%) followed by students (33.8%).

Table 1 - Sociodemographic characteristics of apparently healthy adult population of Addis Ababa,2021.

characteristics		Frequency (N=296)	Percentage (%)
Sex	Male	188	63.5
	Female	108	36.5
Age	18-24	119	40.2
	25-34	110	37.2
	35-44	43	14.5
	45-54	19	6.4
	55-64	3	1
	64 and above	2	0.7
Occupation	Government employee	104	35.1
	Self employed	75	25.3
	Student	100	33.8
	House wife	17	5.7
	Akaki Kality	7	2.4
	Nefas silk lafto	30	101
	Kolfe Keraniyo	39	13.2

Sub city	Gulele	22	7.4
	Lideta	83	28
	Kirkos	20	6.8
	Arada	14	4.7
	Addis Ketema	17	5.7
	Yeka	28	9.5
	Bole	27	9.1
	Lemi Kura	9	3

Clinical, anthropometric and laboratory profiles of study participants

In the study the mean RR (±SD) of participants was 18.48 (±1.86) with absolute values ranging from 14-20 breaths per min. The PR ranged from 60-128 bpm with median value of 83 bpm with IQR(74,90) The SBP and DBP of participants ranged from 90 mmHg-170 mmHg and from 60mmHg-105mmHg respectively with mean SBP(±SD) of 116.3(±13.7) and mean DBP(±SD) of 78(±9.8).

Table 2- clinical profiles of apparently healthy adult population of Addis Ababa,2021.

		RR per min	PR per min	systolic blood pressure in mmHg	diastolic blood pressure in mmHg
Mean		18.48	82.64	116.39	78.00
Median		20.00	83.00	115.00	80.00
Std. Deviation		1.867	11.912	13.721	9.824
Minimum		14	60	90	60
Maximum		20	128	170	105
Percentiles	25	18.00	74.00	110.00	70.00
	50	20.00	83.00	115.00	80.00
	75	20.00	90.00	124.75	83.00

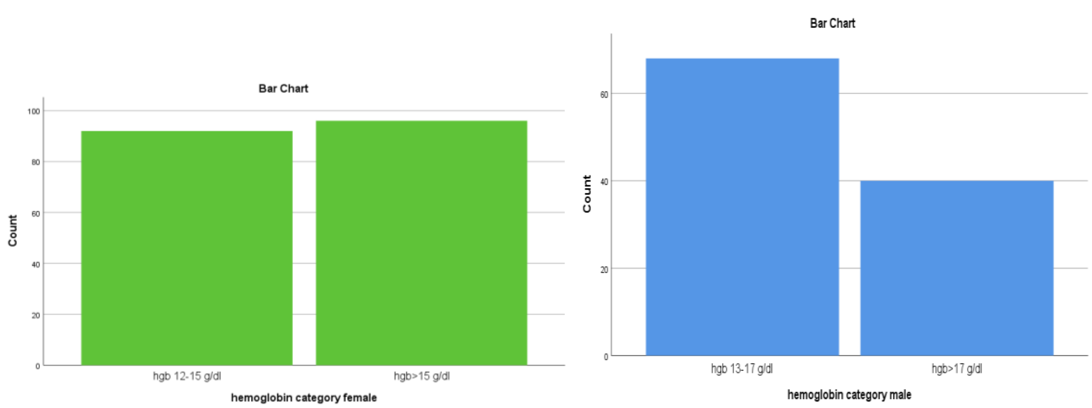
Larger proportion of study participants fall under healthy BMI category consisting 63.2% of the study population. The mean BMI (±SD) of participants was 22.94 (±4.1)

Table 3 - anthropometric profiles of apparently healthy adult population of Addis Ababa,2021

		Frequency	Percent
BMI category	under weight	32	10.8
	healthy weight	187	63.2
	over weight	55	18.6
	obese	22	7.4
	Total	296	100.0

Hemoglobin value ranges from 12-19.6 g/dl among all study participants. The mean hemoglobin (±SD) of participants is 15.59 g/dl (±1.58) with mean hgb value of male participants being 16.53 g/dl (±1.46) and 15.05 (±1.3) for female participants. Among the female participants 48.9% had hgb values ranging 12-15 g /dl while the rest 51% of participants has hgb value >15 g/dl. On the other hand, among the male participants 62.9% had hgb value of 13-17 g/dl while the remaining 37.1% of male participants had hgb value of >17. No anemic participant was included in this study.

Figure 1- Bar graph of sex distribution among designated hgb categories

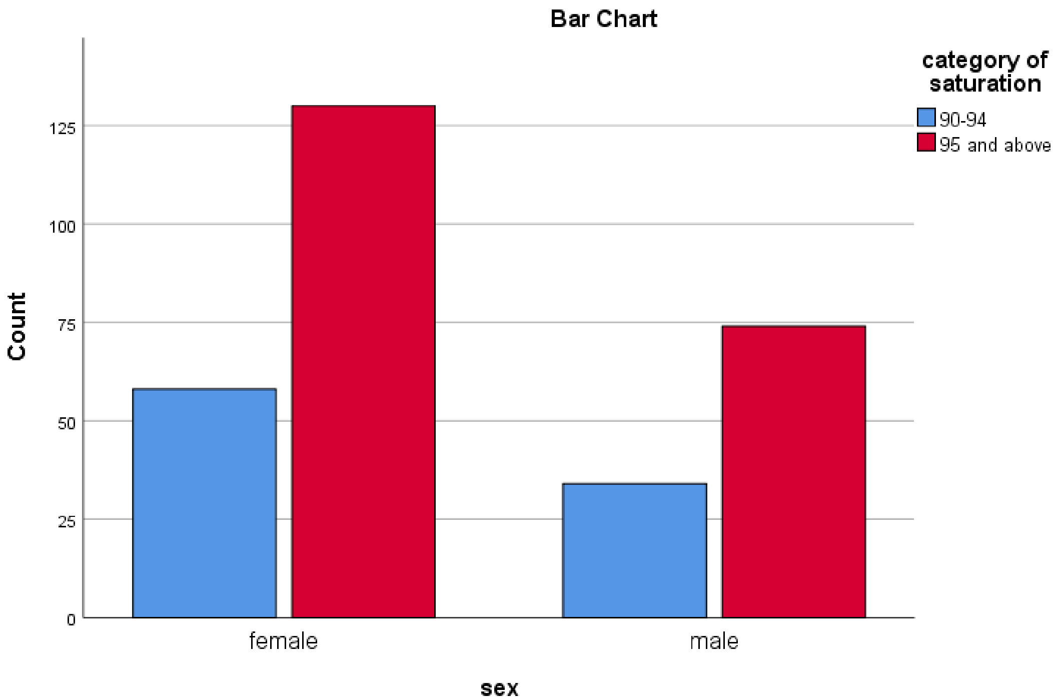


Peripheral oxygen saturation of study participants

The average saturation was calculated from the 3 mean peripheral oxygen saturation recorded using pulse oximeter during data collection. The mean SpO_2 (±SD) of participants is 95.6 % (±1.61) with mean SpO_2 value of male participants being 95.61% (±1.54) and 95.63 (±1.64) for female participants. The minimum and maximum SpO_2 of all participants ranged from 91% to 99%. The calculated average SpO_2 value was further categorized as 90-94 % and 95% and above according the WHO recommended normal value of SpO_2. Among the male participants 68.5%

had saturation value of 95 and above while 69.1% of female participants had similar value of normal SpO_2 level.

Figure 2 – Bar of sex distribution among saturation categories



Among the participants of the study 62 (20.9%) participants had history of living outside Addis Ababa for more than 3 months. From these participants 12 (19%) of them were exposed to low altitude environment during their stay and 7 (58.3%) of them had SpO_2 value of 95% and above. The rest 50 participants were exposed to moderate to high altitude similar to Addis Ababa.

Table 4 - crosstabulation of exposure to different altitudes versus category of spo_2 of apparently healthy adult population of Addis Ababa,2021

		category of saturation		Total
		90-94	95 and above	
	low altitude	5	7	12
	moderate to high altitude	16	34	50
Total		21	41	62

The number of participants included from each sub cities are not uniform as we used convenient sampling. The highest percentage of participants falling in the SpO_2 category of 95% and above were found in Lemi kura sub city (88.9%), a sub city with the 5th highest altitude, while the lowest percentage of participants falling in the SpO_2 of 95% and above category were found in Akaki kality sub city(42.8%) with the lowest altitude among the 11 sub cities.

Table 5 - cross tabulation of category of saturation with their corresponding sub cities and average altitude of each sub cities of apparently healthy adult population of Addis Ababa,2021

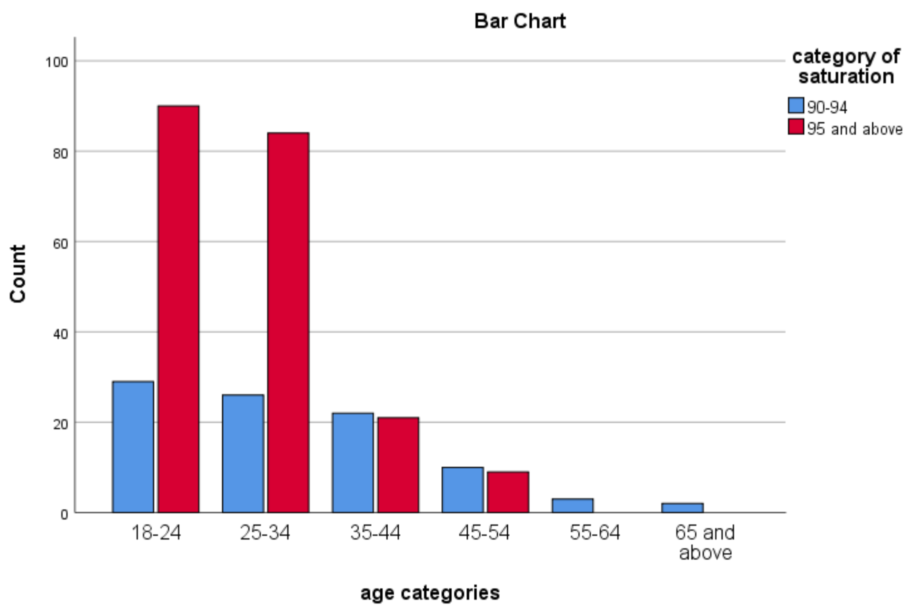
		category of saturation		Total	
		90-94	95 and above		Average altitude of subcities
subcity	Akaki kality	4(57.1%)	3(42.8%)	7	2125 m
	Nefas silk lafto	10(33.3%)	20(66.7%)	30	2224 m
	Kolfe keraniyo	14(35.8%)	25(64.1%)	39	2417 m
	Gulele	8(36.3%)	14(63.6%)	22	2688 m
	Lideta	26(31.3%)	57(68.6%)	83	2327 m
	Kirkos	9(45%)	11(55%)	20	2352 m
	Arada	3(21.4%)	11(78.6%)	14	2436 m
	Addis ketema	2(11.7%)	15(88.3%)	17	2460 m
	Yeka	9(32.1%)	19(67.9%)	28	2471 m
	Bole	6(22.2%)	21(77.8%)	27	2319 m
	Lemi kura	1(11.1%)	8(88.9%)	9	2362 m

Predictors of oxygen saturation in permanent residents of Addis Ababa

The study participant belonging to the different age categories were again grouped under the SpO_2 categories. The age group which has the highest percentage of participants (76.4%) under the 95% and above SpO_2 category is the 25-34 age group, While none of the participants above age 55 achieved SpO_2 of 95% and above.

Fisher's exact test revealed statistically significant association between the two variables (two-tailed p = .000)

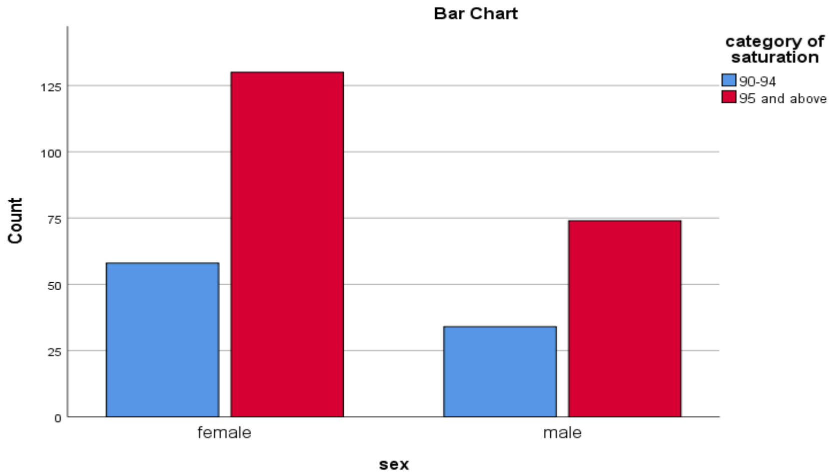
Figure 3 – Bar graph of distribution of age categories against saturation categories



The participants SpO_2 was also categorized according to sex of the participants. More female participants (69.1%) achieved SpO_2 level of 95% and above when compared to their male counterparts(68.5%)

A Chi-Square Test of Independence did not show significant relationship between sex and spo_2, $X^2(1, N=296) = .013, p = .910$.

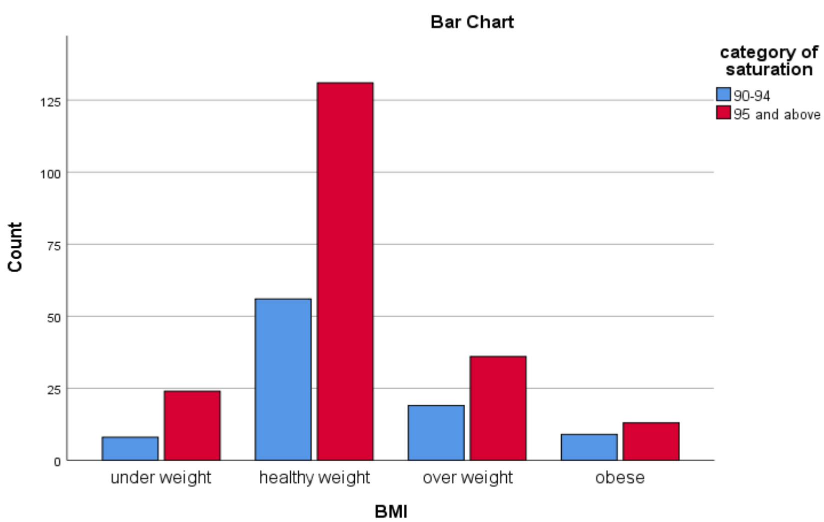
Figure 4 – Bar graph of sex distribution against saturation categories



Among the category of BMI our participants fall on, percentage of participants who achieved spo_2 95% and above from highest to lowest groups are under weight(75%), healthy weight(70.1%), over weight (65.5%) and obese(59.1%).

A Chi-Square Test of Independence did not show significant relationship between BMI categories and SpO_2 categories, $X^2(3, N=296) = .19.65$, p = .580.

Figure 5 – Bar graph of BMI distribution against saturation categories



The hemoglobin of the participants was categorized according to different cut offs for males and females. The female cut of we used is hgb 12g/dl-15g/dl versus >15 g/dl while for males we used 13g/dl -17 g/dl versus >17g/dl.

Among our female participants those with hgb value >15g/dl had more participants (70.8%) grouped under spo_2 of 95% and above versus participants grouped with hgb 12g/dl-15g/dl who had 67.4% of their participants achieve spo_2 95% and above.

In contrast male participants had more participants (69.1%) achieving spo_2 95% and above among the 13g/dl -17 g/dl hgb category while the hgb >17g/dl. category participants achieved spo_2 95% and above in 67.5% of participants.

A Chi-Square Test of Independence did not show significant relationship between hemoglobin categories in female participants and SpO_2 categories, $X^2(1, N=188) = .261$, $p = .610$. Similarly a Chi-Square Test of Independence did not show any significant relationship between hemoglobin categories in male participants and SpO_2 categories, $X^2(1, N=108) = .031$, $p = .861$.

Discussion

This study found a mean SpO_2 (±SD) of 95.6 %(±1.61) with mean SpO_2 value of male participants being 95.61% (±1.54) and 95.63 (±1.64) for female participants. Their SpO_2 value ranged from 91% to 99%. Among the included participants 68.5% of male participants and 69.1% of female participants had saturation value of 95 and above. For analysis purpose the average saturation was categorized to 90-94% and 95% and above according to WHO suggested normal spo_2 of >95% and abnormal spo_2 of <90%[26]. Similar study to our research done to assess the effect of moderate elevation above see level on oxygen saturation reported nadir SpO_2 was 95% at moderate altitude while mean saturation was 98% (98.11 ± 0.8; $p < 0.01$).Both the mean saturation as well as the nadir saturation of our study is lower when compared to this study done by Shmuel G et al [4]. On the other hand, high altitude native Ethiopians living at the elevation of 3530 m were found to have oxygen saturation of 95% which was higher than their high altitude counterpart Tibetans and Bolivians who had saturation of 89% and 92% respectively. While the mean oxygen level at sea level was 97%. This saturation level of Ethiopians residing in highlands is close to the average spo_2 measured in our study.[27]

The mean Hgb of the study population was found to be 15.59 g/dl (±1.58) with mean hgb value of male participants being 16.53 g/dl (±1.46) and 15.05 (±1.3) for female participants. Among our female participants those with hgb value >15g/dl had more participants (70.8%) grouped under spo_2 95% and above while male participants had more participants (69.1%) achieving spo_2 95% and above among the 13g/dl -17 g/dl hgb category. A Chi-Square Test of Independence was performed to assess the relationship between hemoglobin categories in both sexes against the spo_2 categories and there was no significant association found with , $p = .610$ and $p = .861$ for female and male hgb categories respectively.

In the study done on high altitude residing populations mean hemoglobin was found to be 17.9 g/dl for males and 16.8 g/dl for female Bolivians, 16.7g/dl for males and 15.0 g/dl for female Tibetans and 15.9 g/dl for males and 15.0 g/dl for female Ethiopians. While hgb value of 15.3g/dl for males and 13.4 g/dl for females were found at sea level. This hgb values of Ethiopian highlanders match closely with the mean saturation measurement done by our study of the sample population of Addis Ababa city which has moderate to high elevation. [22]

Residents of highland terrain are deduced to adapt to the low barometric pressure of oxygen by demonstrating different phenotypes. The Andeans has relatively high hemoglobin while Tibetans have high hypoxic ventilatory response with increased resting minute ventilation to compensate for the relatively lower spo_2. The Ethiopians did not show any of the aforementioned phenotypic adaptive changes so its deduced Ethiopians must have improved oxygen delivery to the circulation and an increase in oxygen affinity of red blood cells as a result of natural selection while the genetic basis of such adaptation still needs to be explored further. [19,20,21,22,]

The sample population of the study included more younger participants median age of 27, IQR (23,33) with the most frequent age category being 18-24 and included more female participants (63.5%) due to increased accessibility of this population via the convenient sampling the study used. The study also managed to include participants from all 11 sub cities of Addis Ababa even if it included unequal proportions of participants from each sub cities.

Larger proportion of study participants fall under healthy BMI category,63.2% of the study population. When we compare the proportion of study participants in each BMI group the least percentage of participants to attain a spo_2 of 95% or more were the obese patients. This observation was similar to a cross sectional survey on predictors of oxygen saturation which reported the frequency of SpO2 ≤ 95% was found to be significantly increased by increasing levels of BMI (OR of BMI ≥35 = 6.2, CI(4.2,9.2)). Our study did not found significant association between BMI groups and saturation category(P=.580) [26]

Similarly male sex and increased age were mentioned among predictors of desaturation. In our study more female participants (69.1%) achieved SpO_2 level of 95% and above when compared to their male counterparts (68.5%) but significant association was not found when chi square test was done between sex categories and saturation categories (p=.910). On the other hand, the age group which has the highest percentage of participants (76.4%) under the 95% and above SpO_2 category is the 25-34 age group, While none of the participants above age 55 achieved SpO_2 of 95% and above. Fisher's exact test done between age categories and SpO_2. Categories showed was statistically significant association between the two variables (two-tailed p = .000) with similar finding to the previously mentioned study

None of our participants had hyper or hypoventilation; and none had PR or BP recording that could lead to hypoperfusion and subsequent decrement of spo_2. The range of PR, RR and BP were, 14-20 breath per minute, 60-128 bpm, 90-170/90-105 respectively. In addition the study has excluded factors that were considered to prevent getting accurate and representative spo_2 like pregnancy, known patients with cardiac or respiratory illness, previous Tuberculosis treatment or previous severe COVID-19 infection, recent respiratory symptoms or infections, current or ex-smoker, individuals with history of exposure to domestic or occupational dust and fumes, significant nail painting and individuals with signs and symptoms of anemia (those with anemia range hgb were later excluded during analysis) like the recommendation of many similar studies.

Strength and imitation of the study

The fact that we were able to obtain actual clinical, anthropometric and laboratory data of our sample population increase the relevance of the study. In addition, this study helps in answering some confusions for clinical decision making as there is lack of similar studies not only in our set up but in other similar moderate to high altitude areas.

Failure of not attaining the whole sample size, not being able to do the data collection with similar analytic gadgets for all the study subjects, unequal representation of the different sub cities and less representation of the older age categories in our study can be mentioned as limitation of this study.

Conclusion and Recommendation

In conclusion the profile of peripheral oxygen saturation of apparently healthy residents of Addis Ababa, who were born and raised in the city and were exposed to moderate to high altitude showed normal range spo_2 in majority as proposed by WHO. In addition, most of the participants had hgb value within the suggested normal cut offs. Thus, we share the previous thought held on Ethiopians having yet undetermined adaptation mechanism for exposure to high altitude as there is no phenotypic effect on their spo_2 or Hgb. Consequently, we recommend to continue using the existing cut off for normal Spo_2 as well as hypoxia when making medical decisions in treating our patients.

References

1. Measures of oxygenation and mechanisms of hypoxemia - UpToDate. Accessed June 27, 2021. https://www.uptodate.com/contents/measures-of-oxygenation-and-mechanisms-of-hypoxemia?search=hypoxia &source=search_result&selectedTitle=1~150&usage_type=default&display_rank=1

2. Pulse oximetry - UpToDate. Accessed June 27, 2021. https://www.uptodate.com/contents/pulse-oximetry?search=hypoxia &topicRef=1647&source=see_link

3. Jubran A. Pulse oximetry. *Crit Care*. 2015;19(1). doi:10.1186/s13054-015-0984-8

4. Goldberg S, Buhbut E, Mimouni FB, Joseph L, Picard E. Effect of moderate elevation above sea level on blood oxygen saturation in healthy young adults. *Respiration*. 2012;84(3):207-211. doi:10.1159/000336554

5. High-Altitude Cardiopulmonary Diseases: Physiologic Effects of Altitude, Effects of Chronic Hypoxia, Pulmonary Vascular Hyperreactivity. Accessed August 30, 2021. https://emedicine.medscape.com/article/1006029-overview

6. High altitude illness: Physiology, risk factors, and general prevention - UpToDate. Accessed June 27, 2021. https://www.uptodate.com/contents/high-altitude-illness-physiology-risk-factors-and-general-prevention?search=altitiude&source=search_result&selectedTitle=1~128&usage_type=default&display_rank=1

7. Brutsaert TD. Human adaptation to high altitude. *Hum Evol Biol*. Published online 2010:170-191. doi:10.1017/CBO9780511781193.015

8. Discover the climate and geography of Ethiopia. Accessed June 27, 2021. https://www.worldtravelguide.net/guides/africa/ethiopia/weather-climate-geography/

9. Geography of Ethiopia - Alchetron, The Free Social Encyclopedia. Accessed June 27, 2021. https://alchetron.com/Geography-of-Ethiopia

10. Yohaness S, Mekasha A. *OXYGEN SATURATION AMONG UNDER-FIVE CHILDREN LIVING AT MODER-ATE ALTITUDE, ADDIS ABABA, ETHIOPIA*. Vol 58.; 2020.

11. Feyissa G, Zeleke G, Bewket W, Gebremariam E. Downscaling of Future Temperature and Precipitation Extremes in Addis Ababa under Climate Change. *Clim 2018, Vol 6, Page 58*. 2018;6(3):58. doi:10.3390/CLI6030058

12. Kolfe Keranyo Map - Addis Ababa, Ethiopia - Mapcarta. Accessed December 6, 2021. https://mapcarta.com/35847358

13. Elevation of Kirkos, Addis Ababa, Ethiopia - Topographic Map - Altitude Map. Accessed December 6, 2021. https://elevation.maplogs.com/poi/kirkos_addis_ababa_ethiopia.483270.html

14. Luks AM, Swenson ER. Pulse oximetry at high altitude. *High Alt Med Biol*. 2011;12(2):109-119. doi:10.1089/ham.2011.0013

15. Perkins GD, McAuley DF, Giles S, Routledge H, Gao F. Do changes in pulse oximeter oxygen saturation predict equivalent changes in arterial oxygen saturation? *Crit Care*. 2003;7(4):R67. doi:10.1186/cc2339

16. LA J, JE O, NG P. Meta-analysis of arterial oxygen saturation monitoring by pulse oximetry in adults. *Heart Lung*. 1998;27(6):387-408. doi:10.1016/S0147-9563(98)90086-3

17. Rooks, M.G and Garrett, W.S 2016. 乳鼠心肌提取 HHS Public Access. *Physiol Behav*. 2017;176(3):139-148. doi:10.1056/NEJMc2029240.Racial

18. Moore LG. Measuring high-altitude adaptation. *J Appl Physiol*. 2017;123(5):1371-1385. doi:10.1152/japplphysiol.00321.2017

19. Beall CM, Decker MJ, Brittenham GM, Kushner I, Gebremedhin A, Strohl KP. *An Ethiopian Pattern of Human Adaptation to High-Altitude Hypoxia*.; 2002. www.pnas.orgcgidoi10.1073pnas.252649199

20. Alkorta-Aranburu G, Beall CM, Witonsky DB, Gebremedhin A, Pritchard JK, Di Rienzo A. The Genetic Architecture of Adaptations to High Altitude in Ethiopia. *PLoS Genet*. 2012;8(12). doi:10.1371/journal.pgen.1003110

21. Huerta-Sánchez E, DeGiorgio M, Pagani L, et al. Genetic Signatures Reveal High-Altitude Adaptation in a Set of Ethiopian Populations. *Mol Biol Evol*. 2013;30(8):1877-1888. doi:10.1093/molbev/mst089

22. Windsor JS, Rodway GW. Heights and haematology: The story of haemoglobin at altitude. *Postgrad Med J*. 2007;83(977):148-151. doi:10.1136/pgmj.2006.049734

23. Akunov A, Sydykov A, Toktash T, Doolotova A, Sarybaev A. Hemoglobin changes after longterm intermittent work at high altitude. *Front Physiol*. 2018;9(NOV):1-7. doi:10.3389/fphys.2018.01552

24. Hemoglobin concentration of high-altitude Tibetans and Bolivian Aymara. Accessed August 7, 2021. https://onlinelibrary.wiley.com/doi/epdf/10.1002/%28SICI%291096-8644%28199807%29106%3A3%3C385%3A%3AAID-AJPA10%3E3.0.CO%3B2-X

25. Gochicoa-Rangel L, Pérez-Padilla JR, Rodríguez-Moreno L, et al. Altitude Above Sea Level and Body Mass Index as Determinants of Oxygen Saturation in Children: The SON@ Study. *Rev Invest Clin*. 2015;67(6):366-371.

26. Vold ML, Aasebø U, Hjalmarsen A, Melbye H. Predictors of oxygen saturation ≤95% in a cross-sectional population based survey. *Respir Med*. 2012;106(11):1551-1558. doi:10.1016/j.rmed.2012.06.016

27. Beall CM. Andean, Tibetan, and Ethiopian patterns of adaptation to high-altitude hypoxia. *Integr Comp Biol*. 2006;46(1):18-24. doi:10.1093/icb/icj004

Annex

Data collection format

Table 1 Eligibility criteria

Inclusion Criteria	
Is the individual older than 18 years?	Yes□ No□
Is the individual permanent resident of Addis Ababa?	Yes□ No□
Does the individual has accessible recent complete blood count determination over the past 3 months ?	Yes□ No□
Exclusion Criteria	
Is the individual pregnant? (when applicable)	Yes□ No□
Does the individual have any known cardiac or respiratory illness?	Yes□ No□
Does the individual have previous TB Infection?	Yes□ No□
Does the individual have previous severe COVID-19 infection?	Yes□ No□
Does the individual have recent respiratory symptoms or infections?	Yes□ No□
Does the individual have current cough or shortness of breath?	Yes□ No□
Is the individual Current or ex-smoker?	Yes□ No□
Does the individual have history of exposure to domestic or occupational dust and fumes?	yes□ NO□
Does the nail of individual	Yes□ No□

have significant nail painting?	
Does the individual complain easy fatiguability, tinnitus , light headedness or has conjunctival or palmar pallor?	Yes□ No□

Table 2 Data collection table

variables	Response
Code number	
Age	
Sex	Male□ Female□
Occupation	Student□ Government employee□ self employed□ Housewife□ Farmer□ Other: ______________
Duration of stay in Addis Ababa?	
Sub-city	
How long did the individual lived in the current subcity?	
Have you been out of Addis Ababa for more than 3 months.	
If the answer for the above question is yes, where did you live, duration of stay and since when?	
Weight in Kg	
Height in m	
Hgb in g/dL	
RR per min	
PR per min	
BP in mmHg	
SpO_2 at 0 min	
SpO_2 at 5 min	
SpO_2 at 10 min	

Information Sheet

Title of Project: Peripheral Oxygen saturation measured with pulse Oximetry among healthy adult population in Addis Ababa, Ethiopia.

Name of the Investigators: Dr**.** Bethelhem Berhanu, Dr. Wondwossen Amogne. Dr Tewodros Haile

My name is Dr.______________________, and I am working with the department of internal medicine. You are invited to participate in this study. Before you decide to take part, it is important for you to understand why this research is being done and what it involves. Please take time to read/listen to the following information carefully. Raise question if there is anything not clear. Thank you for the time you.

Background to the study.

We would like to see the effect of moderate to high elevation of altitude, such like in that of Addis Ababa, on the peripheral oxygen saturation of its resident and get the range of peripheral oxygen saturation of the permanent residents of Addis Ababa. We will be measuring your peripheral oxygen saturation by pulse oximeter and we will take basic anthropometric measurements, and you will be asked some background sociodemographic data and we will retrieve your recent complete blood count result.

Possible harms. There is no harm in participating in this study.

Time. It will take approximately 15 minute for you to participate in this study

Benefits. The findings of the study may help medical professional to practice on evidence-based manner according to the study result.

Confidentiality. All information which is collected about you during the research will be strictly confidential.

Autonomy. All the information you give us is highly valuable to the study. It is up to you to decide whether to take part or not. If you decide to participate, you will be given this information sheet to keep and be asked to sign a consent form. you can withdraw from the study any time.

What will happen to the research? The data will be collected over three months period and the result will be available in six months' time, and we hope to disseminate the result publishing it on national and/or international journals.

Who is organizing and funding the research? Research is funded by Addis Ababa University. The research will be reviewed by the Institutional Review Board of College of health Sciences, Addis Ababa University.

Thank you in advance!

PI address: Bethelhem Berhanu, MD

Internal Medicine Resident at Addis Ababa University

Mob. No.: 0912138528

e-mail: betiberhan@yahoo.com

Informed Consent Form

I confirm that I have read/have been read to me and understand the information provided above and I also understand that my participation is voluntary.

I agree to take part in the above-mentioned study

Name of participant___________________________

Signature _______________________

Date___________________

Investigators Signature Form

I agree to conduct the study in accordance with the relevant, current protocol and will not make changes to the protocol without permission of Department of Internal Medicine, except when necessary, to protect the safety, rights, or welfare of study participants. I agree to personally conduct or supervise this study. I will ensure that the requirements relating to obtaining informed consent and Ethics Committee (EC) or Institutional Review Board (IRB) review and are met. I agree to maintain adequate and accurate study records and to make those records available for inspection by the department or unit heads, hospital administrators, and/or other applicable regulatory entities. I also agree to promptly report to the EC/IRB all changes to the study and all unanticipated problems involving risks to human subjects or others. I agree to ensure that all staff members involved in the conduct of this study are informed about their obligations in meeting the above commitments.

Principal Investigator: ________________________________

Signature: ___________________ Date: _____________

የመረጃ ቅጽ

የጥናቱ ርዕስ- በአዲስ አበባ ፣ ኢትዮጵያ ውስጥ ጤናማ በሆነ የጎልማሳ ሕዝብ መካከል የሰውነት ኦክስጅን በ pulse Oximetry ይለካል

አጥኚዎች- ዶ/ር ቤተልሄም ብርሀኑ ዶ/ር ወንድዎሰን አሞኘ ዶ/ር ቴዎድሮስ ሀይሌ

ስሜ **ዶ/ር ቤተልሄም ብርሀኑ** ነው ፣ እኔ ከውስጥ ደዌ ሕክምና ክፍል ጋር እሠራለሁ። በዚህ ጥናት ውስጥ እንዲሳተፉ ተጋብዘዋል። ለመካፈል ከመወሰንዎ በፊት ይህ ምርምር ለምን እንደሚደረግ እና ምን እንደሚጨምር መረዳቱ ለእርስዎ አስፈላጊ ነው። እባክዎን የሚከተሉትን መረጃዎች በጥንቃቄ ለማንበብ/ለማዳመጥ ጊዜ ይውሰዱ። ግልፅ ያልሆነ ነገር ካለ ጥያቄ ያነሳሉ። ስለሰጡን ጊዜ አመሰግናለሁ።

የጥናቱ ዳራ፡-

ልክ እንደ አዲስ አበባ የመካከለኛ እስከ ከፍ ያለ ከፍታ ነዋሪው በተለየ የቋሚ የአዲስ አበባ ነዋሪዎችን የሰውነት አየር ኦክስጅንን መጠን ማግኘት እንፈልጋለን። የእርስዎን የከባቢ ኦክስጅንን ሙሌት በ pulse oximeter እንለካለን እና መሰረታዊ የአንትሮፖሜትሪክ ልኬቶችን እንወስዳለን ፣ አንዳንድ የጀርባ ስነ -ማህበራዊ መረጃዎችን ይጠየቃሉ ፡ የቅርብ ጊዜውን የተሟላ የደም ቆጠራ ውጤትዎን እናመጣለን።

ሊመጡ የሚችሉ ጉዳቶች። በዚህ ጥናት ውስጥ መሳተፍ ምንንም ጉዳት የለውም።

ጊዜ። በዚህ ጥናት ለመሳተፍ በግምት 15 ደቂቃ ይወስዳል

ጥቅሞች። የጥናቱ ግኝቶች የህክምና ባለሙያው በጥናቱ ውጤት መሠረት በማስረጃ ላይ ተመስርተው እንዲያክሙ ሊረዳ ይችላል።

ምስጢራዊነት። በምርምር ወቅት ስለእርስዎ የተሰበሰበው መረጃ ሁሉ በጥብቅ ሚስጥራዊ ይሆናል። እርስዎ የሚሰጡን መረጃ ሁሉ ለጥናቱ ከፍተኛ ዋጋ ያለው ነው። ለመሳተፍ ወይም ላለመሳተፍ መወሰን የእርስዎ ነው። ለመሳተፍ ከወሰኑ ፣ ይህንን የመረጃ ወረቀት እንዲሰጡዎት እና የስምምነት ቅጽ እንዲፈርሙ ይጠየቃሉ። በማንኛውም ጊዜ ከጥናቱ መውጣት ይችላሉ።

ጥናቱ ምን ይሆናል? መረጃው በሦስት ወር ጊዜ ውስጥ ይሰበሰባል ውጤቱም በስድስት ወር ጊዜ ውስጥ የሚገኝ ሲሆን ውጤቱን በብሔራዊ እና/ወይም በዓለም አቀፍ መጽሔቶች ላይ ያታተማል ብለን ተስፋ እናደርጋለን።

ምርምሩ በአዲስ አበባ ዩኒቨርሲቲ የገንዘብ ድጋፍ የሚደረግለት ነው። ጥናቱ በአዲስ አበባ ዩኒቨርሲቲ የጤና ሳይንስ ኮሌጅ በተቋማዊ ግምገማ ቦርድ ይገመገማል

በቅድሚያ አመሰግናለሁ!

አድራሻ- ዶ/ር ቤተልሄም ብርሀኑ

ውስጥ ደዌ ሕክምና ክፍል ሬዚደንት በአዲስ አበባ ዩኒቨርሲቲ ፣

Mob. No.: 0912138528 e-mail: betiberhan@yahoo.com

የፈቃድ መስጫ ቅጽ

ከላይ የቀረበው መረጃ አንብቤ/ተነብቦልኝ ተረድቻለሁ እንዲሁም የእኔ ተሳትፎ በፈቃደኝነት ላይ የተመሰረተ መሆኑን ተረድቼ ከላይ በተጠቀሰው ጥናት ውስጥ ለመሳተፍ ተስማምቻለሁ።

ስም---

ፈርማ------------------

ቀን------------------

የማካተ ቻ መስፈርት	
ግለሰቡ ከ 18 ዓመት በላይ ነው?	አዎ □ አይደለም □
ግለሰቡ አዲስ አበባ የተወለደ እና በአሁኑ ግዜ የአዲስ አበባ ቋሚ ነዋሪ ነው?	አዎ □ አይደለም□
ግለሰቡ ባለፉት 3 ወራት ውስጥ የቅርብ ጊዜውን የተሟላ የደም ቆጠራ ውጤት ማግኘት ይችላል?	አዎ □ አይቻልም □
የሁሉም መልስ አዎ ከሆነ ወደ ማግለያ መስፈርት ዪቀጥሉ	

የማግለያ መስፈርት	
ግለሰቡ ነፍሰ ጡር ነው? (ተፈጻሚ በሚሆንበት ጊዜ)	አዎ □ አይደለም □
ግለሰቡ የሚታወቅ የልብ ወይም የመተንፈሻ በሽታ አለበት?	አዎ □ አይደለም □
ግለሰቡ ከዚህ በፊት በቲቢ ኢንፌክሽን ተየዞ ያውቃል?	አዎ □ አይደለም □
ግለሰቡ ከዚህ ቀደም በኮቪድ -19 ኢንፌክሽን ተየዞ ያውቃል?	አዎ □ አይደለም □
ግለሰቡ የቅርብ ጊዜ የመተንፈሻ በሽታ ምልክቶች ወይም ኢንፌክሽኖች አሉት ?	አዎ □ አይደለም □
ግለሰቡ የአሁኑ ሳል ወይም የትንፋሽ እጥረት አለበት?	አዎ □ አይደለም □
ግለሰቡ የአሁኑ ወይም የቀድሞ አጫሽ ነው?	አዎ □ አይደለም □
ግለሰቡ ለቤት ውስጥ ወይም ለሥራ አቧራ እና ጭስ የመጋለጥ ታሪክ አለው ?	አዎ □ አይደለም □
ግለሰቡ ጉልህ የሆነ የጥፍር ቀለም አለው?	አዎ □ አይደለም □
ሁሉም የማግለያ መስፈርት ላይ ያሉት ጥያቄዎች መልሱ አይደለም ከሆነ ወደ ዳታ መሰብሰቢያ ቅጽ ይሂዱ	

<u>ዳታ መሰብሰቢያ ቅጽ</u>

ኮድ	እድሜ	ፆታ	ሥራ ተማሪ □ የመንግስት ሰራተኛ □ ነጋዴ □ የቤት እመቤት □ ገበሬ □ ሌላ____________	ክፍለ ከተማ	በዚ ክፍለ ከተማ ስነት ግዜ ኖሩ	ከአዲስ አበባ ከ3 ወር በላይ ወተው ያውቃሉ	ከ3 ወር በላይ ወተው ካወቁ፣ መቼ ነበር፤ ለስንት ጊዜ ቆዩ	ክበደት በኪሎግራም	ቁመት በሜትር	Hgb in g/dL	RR per min	PR per min	BP in mm Hg	SpO_2 at 0 min	SpO_2 at 5 min	SpO_2 at 10 min