Deanship of Graduate Studies

AL-Quds University

Effect of Low Altitude on Complete Blood Count Parameters

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M.Sc. Thesis

Jerusalem-Palestine

1435 Hijri / 2013 AD

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A thesis submitted in partial fulfillment of requirements for the degree of Master in Medical Laboratory Sciences/Hematology Track, Faculty of Health Professions – Al-Quds University

1435 Hijri / 2013 AD

Al-Quds University

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Department of Medical Laboratory Sciences

Thesis Approval

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Master thesis Submitted and accepted, Date: 7/12/2013.

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Dedication

إلى كل من يعين طالب علم ويسهّل له طريقه

To everybody who helps science seeker and pave a way to him.

إلى كلّ عصاميّ مثابر يؤمن بأن الإنجاز يعتمد عليه بالدرجة الأولى، لا على الآخرين

To everyone who a self-made, studious, and believe that success, realization and achievement depends basically on himself and not on others.

إلى كل أمّ و أب و أخت وأخ يكرّسون أنفسهم لتشجيع أبناءهم على النجاح والتفوق و الإبداع

To every mother, father, sister and brother whom devote themselves to encourage their sons for success, excellence and creativity.

إلى كل من يساهم في بناء مدرسة أو جامعة أو يشتري حقيبة لتلميذ

To every who help and contribute in building a school, university or buy a school-bag to schoolboy.

إلى والديّ، و إلى زوجتي الغاليه وأبنائي، و أساتذتي الأفاضل

To my parents, my wife and children, and my teachers.

إلى كل من وقف بجانبي في إنجاز هذا العمل أ وفي رحلتي العلميّة أوفي حياتي

To everybody helped me to execute this work or during my study and in my life.

Jabr Jamil Ibrahim Haj-Ali

Declaration:

I Certify that this thesis submitted for degree of Master of Medical Laboratory Sciences Hematology track is the result of my own research, except where otherwise acknowledge, and that this study (or any part of the same) has not been submitted for higher degree to any other university or institution.

Signed

Jabr Jamil Ibrahim Haj-Ali

Date: 20 / 12 /2013.

Abstract

Reduction in oxygen partial pressure in the air at high altitude leads to reduced oxygen saturation in the arteries and results in erythropoietin production, which stimulates erythropoiesis to restore the appropriate oxygenation status. There are many studies describing the acclimatization to high altitude and its effect on Complete Blood Count (CBC) parameters and on exercise. Most of these studies proved the increase in Hemoglobin (Hgb), erythropoiesis and erythropoietin secretion, while there is lack of available information about the effect of being below sea level on CBC test results. This study aimed to evaluate the CBC parameters of people who live below sea level, for the first time in Palestine, in comparison with those who live above sea level. Moreover, it is expected by the end of this study that we will be able to verify the applicability of the reference ranges that have been adopted from other sources and to assess if we need to establish new reference ranges for people living in Jericho (about 300 meters below sea level) and Ramallah (about 900 meters above sea level).

The study was conducted in February, 2013, where four secondary schools were chosen for the study: two in Jericho and two in Ramallah. Three hundred and twenty participants were randomly chosen from eleventh and twelfth grade male students during this study, where the age of students ranged from 16 to 19 years old. Twenty three of them were excluded as they did not fit the given criteria. Blood samples were collected from the rest two hundred ninety seven participants, and analyzed for CBC. CBC data and questionnaires were analyzed using t-test between two means for independent samples. Results for the differences between means showed that Red Blood Cell counts ($P=0.005$), Hgb ($P=0.001$), and Hematocrit ($P=0.002$) have mean values which are statistically higher among those who live about 900 meter above sea level than among those who live about 300 meter below sea level, while Platelet count (PLT) was significantly higher in those who live below sea level ($P < 0.001$).

Results of t-test for reference ranges showed that CBC reference ranges of Palestinians are different in comparison with the applied reference ranges adopted from published reports. Almost all CBC parameters in our study for both groups in Ramallah and Jericho differ significantly from those in the international studies. This justifies the need to establish our own reference ranges for this age group and for adult male population in general.

In conclusion, we found significant difference in hematological parameters (Hgb, Hct, RBC count, and platelet count) in healthy adult students living above and below sea level in a representative population sample, which is also the first study from people living below sea level in Palestine.

Acknowledgment

First and foremost of all, perpetual and eternal thankfulness to Allah who bestowed us the grant of being, the grace of health and blessed my efforts to carry out and execute this research.

My gratitude to Al-Quds University for giving me this opportunity to be one of its students in both bachelor and masters levels, and for giving me the chance to be one of the department graduates in the master program of medical laboratory sciences hematology track. I want also to thank the medical laboratory sciences department represented by the great team of teachers and workers.

I am always grateful to my teachers for their time, patience, lenience, and support who acted with us as fathers, brothers and sisters, and all the time they put us in family atmosphere. Special appreciation to my supervisor Mr. Khalid Younis, the source of my pride; my principal advisor Dr. Mahmoud Srour, the ideal teacher; my exemplary teacher Dr. Akram Kharroubi; the dean of the Faculty of Health Professions.

Gratefulness and thanks are continuous to my great teachers and inspirers Dr. Rasmi Abu Helu for his interest, care and directing; Dr. Hatim Eideh, the head of Medical Laboratory Sciences Department for his humbleness, and willing to help, Dr. Samir Barghouthi and Dr. Mohammad Ayesh who believed in me and for their encourage which raised my self-confidence all times. I really do thank all my teachers at Al-Quds University during my two levels of bachelor and master, Ms. Yumna Shehadeh, Ms. Sahar Jaouni, Ms. Rania Abu-Seir, and Mr. Khadir Shouki. This is a bend of veneration and great respect to all my teachers who taught me not only science but also morals and ethics through being exemplary patterns.

This research would have never been accomplished without the help and approval of the Palestinian Ministry of Education, especially Ms. Maysa' Younis the head of the school's health department at the Palestinian Ministry of Education. I would like to thank her for her help and support. I also want to address my thanks to the heads of schools for their cooperation and assistance they gave me, the students who donated the study samples and colleagues who helped in organizing the phlebotomy process. I would like to thank Mr. Ibrahim Ghannam and Mr. Mohammad Qalalweh for their assistance in Statistical analysis and putting out the study results using SPSS software, and Dr. Youssef baba Khouya from Morocco for his help in proofreading. I want to thank my colleagues the laboratory technicians: Ms. Lubna Asa'ad and Ms. Suha Abu-Wazzeh for their help in organizing, running the samples, data entry and processing and for their support. Lastly, my great love and thanks to my family , my wonderful wife and children for providing me with encourage, support and loving atmosphere. I also thank everybody who gave me a hand and was not mentioned above, thank you all.

Table of contents

List of Tables

List of Figures

List of Abbreviation

AA :	Amino Acid
BMI :	Body Mass Index
CBC :	Complete Blood Count
CD4 :	Cluster Of Differentiation 4
CD8 :	Cluster Of Differentiation 8
CML :	Chronic Myelocytic Leukemia
CMV :	Cytomegalovirus
CV% :	Coefficient Of Variation
D :	Dalton
DIFF :	Differential WBCs Counts
DPG :	2,3-Diphosphoglycerate
EDTA :	Ethylen-Diamin Tetra Acetic Acid
Epo :	Erythropoietin
EpoR :	Erythropoietin Receptors
FBC :	Full Blood Count
Hct :	Hematocrit
Hgb/Hb:	Hemoglobin
HH :	Hypobaric Hypoxia
HIF :	Hypoxia-Inducible Factor
HSC :	Hematopoietic Stem Cell
ICSH :	International Committee For Standardization In Hematology
KAUH:	King Abdullah University Hospital
LC :	Liver Cirrhosis
LDH :	Lactate Dehydrogenase
MCH :	Mean Corpuscular Hemoglobin
MCHC:	Mean Corpuscular Hemoglobin Concentration
MCV :	Mean Corpuscular Volume
MPV :	Mean Platelets Volume
NADH:	Nicotinamide Adenine Dinucleotide
NK :	Natural Killer Cells
PDW :	Platelet Distribution Width

PLT : Platelet Counts
PMNs : Polymorph Nuclear Neutrophils
PO_2 : Oxygen Partial Pressure
PSC : Pluripotential Stem Cell
PV : Polycythemia Vera
RBC : Red Blood Cells
RDW : Red Distribution Width
RR : Reference Range
SD : Standard Deviations
SPSS : Statistical Package For Social Sciences
TAT : Turn Around Time
TfR : Transferrin Receptors
VEGF : Vascular Endothelial Growth Factor
vHL : Von-Hippel Lindau Protein
VO_2 Max: Maximal O_2 Uptake
VTE : Venous Thrombo Embolism
WBC : White Blood Cells

Definitions of keywords

Altitude: The vertical height of an object above sea level (elevation).

Hemogram (**CBC**): The blood test that consists of a white blood cell count (WBC), red blood cell count (RBC), hemoglobin (Hgb/Hb), hematocrit (Hct), red blood cell indices, and a platelet count.

Acclimatization: the response which observed in individuals temporarily exposed to high altitude, and to some extent, it enables them to tolerate high altitudes. In this phase, erythropoiesis is increased, resulting in higher hemoglobin and hematocrit levels to improve oxygen delivery capacity.

Adaptation: Is the process of natural acclimatization where genetical variations and acclimatization play a role in allowing subjects to live without any difficulties at high altitudes.

Accommodation: The initial response to acute exposure to high altitude hypoxia and is characterized by an increase in ventilation and heart rate.

Chapter One: Introduction

1.1.Introduction

Hemogram consists of a white blood cell count (WBC), red blood cell count (RBC), hemoglobin (Hgb/Hb), hematocrit (Hct), red blood cell indices, and a platelet count. It is alternatively called Complete Blood Count (CBC) or Full Blood Count (FBC), which consists of a hemogram plus a differential WBC (Fischbach 2004). CBC is affected by many factors. Altitude is considered one of the most important factors which can exert its effect on hemogram parameters. Individuals living at different altitudes are expected to show different Hemograms. Blood is one of the most responsive tissues in our bodies to the oxygen availability, which means that blood can reflect the inner status of our bodies. There are many physiochemical properties which influence our Hemograms such as nutrition, sex, age, gestation, ethnicity, general health status (diseases), and altitude (Tefferi, 2001; Domenech, et al. 2005; Lewis, et al. 2006). Many studies have addressed the effect of high altitude on hemoglobin, erythropoietin, platelets, and its effect on exercise. Most of the studies confirm an increase in hemoglobin level secondary to an increase in erythropoietin level at high altitude (Al-Sweedan and Alhaj 2012), while there is lack of available information about the effect of being below sea level.

The different types of response mechanisms that the organism uses when exposed to hypobaric hypoxia at high altitude include accommodation, acclimatization, and adaptation. Accommodation is the initial response to acute exposure to high altitude hypoxia and is characterized by an increase in ventilation and heart rate. Acclimatization is observed in individuals temporarily exposed to high altitude, and to some extent, it enables them to tolerate high altitudes. In this phase, erythropoiesis is increased, resulting in higher hemoglobin and hematocrit levels to improve oxygen delivery capacity. Adaptation is the process of natural acclimatization where genetical variations and acclimatization play a role in allowing subjects to live without any difficulties at high altitudes (Gonzales, 2011).

Frequent changes between low and high altitudes provoke adaptations (acclimatization) in red cell mass as occur in high altitude residents. The plasma volume decreases at high altitude and increases again when staying at sea level (Schmidt, 2002). However, while moving between low and high altitude, the total blood volume, hemoglobin concentration and hematocrit, along with the plasma Erythropoietin (Epo) concentration, noticeably oscillate during every hypoxic-normoxic cycle (Schmidt, 2002).

CBC is the most important and frequent test in the diagnostic process (George-Gay and Parker, 2003). CBC requires a small blood sample obtained from venipuncture, or finger puncture, or from the heel of infants. It is used to evaluate the general health status and for screening and monitoring a lot of diseases as part of a routine medical examination.

Many kinds of disease investigation need CBC test to the degree that the request that does not include CBC may be considered incomplete. The CBC can be a powerful diagnostic tool. Appropriate evaluation of all aspects of the CBC can lead to a specific diagnosis or assist in ruling out many diseases. To gain the full utility of the CBC, it preferred to be used in conjunction with a good history and physical examination as well as with additional components of the minimum database such as chemistry panel and urinalysis (Barger, 2003). It provides an effective answer to the clinical request and helps clinicians in decision making (Sciacovelli et al., 2006). It consists of many important hematological parameters depending on the advancement and technology of the cell counter used.

In addition to its efficacy in diagnosing the causes of many diseases as a screening test, it also confirm certain cases like infections when present, and paves the way for further investigations (http://labtestsonline.org/understanding/analytes/cbc/tab/test).

The main nine parameters of CBC are the Red Blood Cells (RBCs), Hemoglobin (Hgb), Hematocrit (Hct), Red Blood Cell Indices. They include Mean Corpuscular Volume (MCV), Mean Corpuscular Hemoglobin (MCH), Mean Corpuscular Hemoglobin Concentration (MCHC), Red Blood Cell Distribution Width (RDW), White Blood Cells (WBCs), and Platelets (PLTs) counts (Dixon, 1997). Mean platelet volume (MPV) and platelet distribution width (PDW) are other useful hematologic parameters used in monitoring recovery from thrombocytopenia (Buttarello 2004). Besides, (MPV) with platelet distribution width (PDW) are used to evaluate patients suffering from liver cirrhosis (LC) and thrombocytopenia (Luzzatto et al., 1988) along with patients with myocardial infarction (Erne et al., 1988).

Nowadays most of cell counters are capable of performing the CBC in very short Turn Around Time (TAT) about one minute, with relatively low cost. This provides strong encourage to clinicians to utilize it for clinical diagnosis and for management of a patient.

Every parameter in CBC has its own Reference Range (RR) value (Normal Value)/ Reference Interval (Table 1.1) (Hoffbrand et al., 2011). Any decrease or increase in any parameter of CBC indicates for a certain disorder which might be inquired or inherited. It is essential that all laboratories use similar reference values for distinguishing the normal from the abnormal (Lewis, 1988). Laboratory data influence 70% of medical diagnoses. This fact indicates that the laboratory is a major aid to the clinicians who have requested the tests. Furthermore, it means that the laboratory must try to reach the goal of zero defects. Thus, it is repeatedly recommended throughout the literature to establish the own reference ranges for any laboratory or population. It is proven that there is a considerable difference in hemogram reference ranges upon the demographic and ethnic variables (Bain et al., 1984; Roshan et al., 2009). Existing reference intervals need to be verified or validated because they were admitted decades ago using obsolete methods and instrumentations (Emerk, 2008). There are evidences that values adopted from manufacturers are not applicable to all populations. Additionally, normal values provided by different laboratory manuals and books do not solve this problem (Roshan et al., 2009). It was also proved that CBC parameters may differ depending on the blood sampling site (Kayiran et al., 2003).

Table 1.1: Normal values for Hemogram (CBC) main parameters adopted from (Harmening, 2006; Hoffbrand et al., 2011).

	Reference	**Male**	**Female**	**Units**
WBC	Hoffbrand	4.0-11.0		k/uL
	Harmening	**4.8 – 10.8**		
RBC	Hoffbrand	4.5-6.5	3.9-5.6	$*10^6$/uL
	Harmening	**4.7 – 6.1**	**4.2-5.4**	
Hgb	Hoffbrand	13.5-17.5	11.5-15.5	g/dL
	Harmening	**14.0-18.0**	**12.0-16.0**	
Hct	Hoffbrand	40-52	36-48	%
	Harmening	**42.0-52.0**	**37.0-47.0**	
MCV	Hoffbrand	80-95		Femtoliter (fL)
	Harmening	**80-100**		
MCH	Hoffbrand	27-34		Picogram (pg)
	Harmening	**27-31**		
MCHC	Hoffbrand	30-35		Gram/dL %
	Harmening	**32-36**		
PLT	Hoffbrand	150-400		k/uL
	Harmening	**150-350**		
RDW	Hoffbrand	**11.5-14.5**		%
	Harmening			

According to the IFCC1 C28-P3 document, for establishing a reference interval for a specific analyte, reference individual is a selected person who meets the defined criteria for reference individuals. All reference individuals in the general population refer to reference population. Reference sample groups are individuals within the reference population pool. Reference values are the values that obtained from the test results of reference sample group. Reference values are used for evaluation of the reference distribution. Reference limits are calculated from reference values. Finally, those values that are located between the lower and upper of the reference limits are reference intervals (Emerk, 2008).

Judgment of CBC results, either decreased or increased is implied, from a statistically determined reference range that represents 95% of the normal population. Hence, accurate interpretation of a particular Hgb result, for instance, requires the use of an appropriate age-, sex-, and race- adjusted reference range and realization that a value that is slightly below normal may be a statistical outlier rather than an indication of abnormal value (Tefferi, 2001). More problematic are the inherent variables which appear as a result of adaptation to environment (especially altitude). These factors must be recognized when physiologically establishing normal values (Lewis, 2012). In general, hemoglobin levels are 1-2 gram lower in women and African men than in white males (Tefferi, 2001). Typically, laboratory teams adopt the reference ranges provided to them by manufacturers, neither establishing reference ranges themselves nor even verifying the applicability of those reference ranges to their patients (Gary , 2008).

Jericho city is the lowest inhabited place on the planet located in Palestine, about 300 meters below the sea level (Palestinian Meteorology Center, 2013). There are many previous studies describing the effect of high altitude on blood and CBC parameters. (Faura et al., 1969; Savourey et al., 2004; Grocott et al., 2007; Alper et al., 2009; Al-Sweedan and Alhaj, 2012; Son et al., 2012). Most of these studies are comparing sea level with different altitudes, while very few of them investigated the influence of being below sea level.

Reference ranges used in Palestine are adopted from the literature and derived from studies that were not done on Palestinians, and there is no sufficient data available about hematological reference ranges for Palestinian population especially for those living below sea level as a unique place.

This study is the first one in Palestine that aimed, on one hand, to evaluate the CBC of those living below sea level, and comparing between those living about 300 meters below sea level (Jericho people), and those living about 900 meters above sea level (Ramallah people). On the other hand, this study aimed in part at evaluating the used reference ranges of CBC parameters in Palestine, and to assess the need for establishing new reference ranges for Jericho people if needed.

1.2. Objectives of the study

CBC is a multi-parameter simple automated test where every parameter is considered a specific test and has its medical value in medical diagnosis process. These main parameters include WBC, RBC, and their indices (MCV, MCH and MCHC), Plts counts in addition to Hgb, HCT, and RDW are included in this study.

Hemogram is frequently ordered for any person seeking medical help, and most of other hematologic tests are referred in their planning to the information derived from the hemogram indicators (Besarab and Soman, 2005).

This study will evaluate the hemogram for people living about 300 meters below sea level for the first time in Palestine. It will also compare their hemogram with the hemogram of those living about 900 meters above sea level, and will evaluate to some extent the applicability of the used reference ranges of CBC in Palestine.

1.3. Statement of the problem

Palestine has the lowest point in the world where Jericho city is located about 300 meters below the sea level while Ramallah city is 900 meters above the sea level (Palestinian Meteorology Center, 2013).This difference in altitudes results in climate variations and atmospheric diversity (Table 1.2) that may affect the human physiologic responses and adaptation. Blood is one of the most responsive and affected systems in the body to such differences, particularly the RBC's and the related parameters. There is lack of information available in the literature about the effect of being below sea level on hemogram parameters. Many studies have reported the influence of high altitude on human hemogram parameters and its effect on athletes performance. Many of these studies have yielded conflicting results, and there is a rarity in the evaluation to the effect of living below sea level.

It's expected that People living at different altitudes will have different hemogram (CBC) results. There are many factors affecting the hemogram parameters such as, age, sex, PO_2, smoking, diet, genetic background, erythropoietin production, diseases and so forth. There are different PO_2 levels at different altitudes. The altitude factor is one of the most important factors that may exert its effect on the RBC’S and related parameters. Therefore, this study intends to evaluate the hemogram of those living below sea level for the first time in Palestine. Besides, it is expected to investigate if there is a significant difference in the hemograms between those living in Jericho and those living in Ramallah, and if this difference (if present) is related to altitude difference. If so, do we need to establish a reference range for CBC parameters for those living in Jericho if differ significantly from those living in Ramallah?

Table 1.2:Altitude and climate variations of the two study cities, Jericho and Ramallah. Provided from Palestinian Meteorology Center, 2011.

	Altitude meter	Pressure, mb (mmHg)	Temperature Celsius
Jericho	260 below sea level	Range : 1034-1052 Mean: 1043.25 (786 mmHg)	Average minimum: 16.0 Average maximum: 33.0
Ramallah	856 above sea level	Range: 914-920 Mean: 916.8 (687 mmHg)	Average minimum: 9.0 Average maximum: 24.0

mb: mellibar

1.4. Justification

Hemogram, alternatively called Complete Blood Count (CBC), is one of the most commonly ordered blood tests to evaluate patients. It is often used as a broad screening test to determine an individual's general health status. It can be used to screen for a wide range of conditions and diseases. CBC also helps diagnose various conditions such as anemia, infection, inflammation, bleeding disorders or leukemia. It also monitors the condition or effectiveness of treatment after a diagnosis is being established.

It is proved now that there is a worthy difference in CBC reference ranges according to the demographic and ethnic variations (Roshan et al., 2009). There is much evidence that reference ranges adopted from manufacturers are not applicable for all populations.

Furthermore, normal values provided by different literature resources do not solve this problem (Roshan et al., 2009).

There is a need to provide a description of the hemogram of those people living below the sea level as there is lack in such data. Jericho as a unique inhabited place on the planet located below sea level, which creates a strong motivation to us to conduct this study. Testing people at different altitudes in Palestine can assess the need for a different reference range. There are a lot of recommendations through the literature to establish the own reference range, because it is one of the most important tasks of the medical laboratory to provide an effective answer to clinical request to help clinicians in making decisions. Thus, providing a reliable reference value with the results is crucial for accurate diagnosis.

The reference ranges, which are provided by other sources, deserve more scrutiny. It is expected by the end of this study that we will be able to verify the applicability of the reference ranges that have been adopted from other sources and to assess if we need to establish new reference ranges for this age group living in Jericho and Ramallah.

Reference range value represents the corner stone for the clinicians to evaluate the CBC results. Physicians rightly expect that medical laboratory should provide a reference range in accompany with their results, which would help them in adequate judgment of the diagnosis. Any laboratory result without a valid reference range will be meaningless for the clinician. This study is expected in part to evaluate the CBC reference ranges that are used in Palestine in order to show the need for local CBC reference ranges.

1.5. Significance of the study

CBC parameters are affected by oxygen availability at different altitudes. Literature is rich with studies comparing between CBC at sea level with CBC at different altitudes, while there is lack of available information about the effect of low altitude on CBC test results. This study is expected to compare the CBC of people who live below sea level, for the first time in Palestine, with those live above sea level.

The importance of this study lies in providing more effective answers to the clinical request and helping clinicians in more accurate understanding and interpretation for the CBC results. It is expected from the results of this study, on one hand, to change the way in which medical practitioners and field workers look at CBC results, influencing the forthcoming researches, and to create long-term interest in the problem of being below sea level. On the other hand, it is expected also, with completion of this study, to be able to evaluate to some extent the applicability of the used CBC reference ranges that adopted from the literature on Palestinian people, and assess the need for establishing a new reference ranges of CBC for Jericho city inhabitants.

Thus, this study is the first one in Palestine and the second at the level of the world to investigate the CBC results below sea level. Conducting such study for the first time in Palestine and being the only one evaluating the CBC reference ranges is expected to produce substantially novel knowledge that could be of pivotal importance, along with impact on physicians, researchers, patients, and local community.

1.6.Organization of the study

The study is divided into five chapters. This chapter presents an introduction for the study, objectives of the study, statement of the problem, justification, and significance of the study. The second chapter reviews the literature related to the research topic. The third chapter presents the methodology followed in collecting and analyzing the data. It describes the research questions and hypothesis, the setting and participants, the materials, and data analysis. The fourth chapter deals with data analysis and the results obtained on the basis of the investigated research questions. The last chapter is devoted to a discussion of the findings, pedagogical implications, and general conclusions inspired from the findings.

Chapter Two: Review of Literature

2.1. Introduction

Zuntz was the first scientist who studied the effects of lowered oxygen partial pressure (PO_2) on the human body in a hypobaric chamber. He worked together with Adolf Loewy (1862-1936), Angelo Mosso (1846-1910), and Arnold Durig (1872-1961). In 1902, Zuntz and the Austrian Hermann von Schroetter (1870-1928) made two balloon ascents up to 5,000m in Berlin. A synopsis of these studies was published by Zuntz in 1906, his famous book (High altitude climate and mountain-touring) (Gunga and Kirsch 1995).

After that, many researchers have focused on the effect of high altitude on erythropoiesis (Jensen and Alt, 1945; Stohlman and Brecher, 1957; Faura et al., 1969). In addition, the effect of altitude and hypobaric hypoxia on other CBC parameters, blood chemistry, hemostasis, chronic diseases and on exercise continuously enriched the literature (Pustovalov and Voronkov, 1988; Julian et al., 1993; Joanny et al., 2001; Christensen et al., 2002).

Under hypobaric hypoxia, regulation of erythropoiesis is directed to prevention of tissue hypoxia (Makeshova et al., 2004). Chronic exposure to high altitude reduces maximal O_2 uptake (VO_2max), and the arterial O_2 saturation at maximum effort decreases (Cymerman et al., 1989). There are many studies which state that hypobaric hypoxia at high altitude stimulates erythropoiesis (Lewis, 2012). Chronic sporadic exposures to simulated high altitudes for a period of 6 weeks yielded a marked polycythemia and increase in the total blood volume (Demopoulos et al., 1965). Other studies on athletes demonstrated that living at moderate altitude, (1550-2050m) and training low, near sea level (450-500 m) significantly increase VO_2max and RBC mass for both genders (Levine and Stray-Gundersen, 1997; Christoulas et al., 2011).

There is a myriad number of studies verifying the increase in hemoglobin level as a result to rise in erythropoietin level at high altitude (Gray et al., 1975; Richalet et al., 1994; Gunga et al., 2003; Heinicke et al., 2003), but there is a scarce data on hemogram of those living at low altitude. It is well documented that ascending to high altitude is associated with the increment of red cell mass. Additionally, there is a rapid elevation in erythropoietin level on ascent to altitude with a reduction in plasma volume (Al-Sweedan and Alhaj, 2012). 2,3-Diphosphoglycerate (2,3-DPG) levels increased throughout Hypobaric Hypoxia (HH) and an inverse linear relationship was found between 2,3-DPG and Epo at the end of HH. The sensitivity but not the gain of the Epo response to hypoxia was modified by altitude acclimatization. Higher 2,3-DPG levels could partly explain this decreased sensitivity of the Epo response to hypoxia. Altitude acclimatization modifies the control of erythropoiesis not only at sea level, but also during a subsequent hypoxia (Savourey et al., 2004; Son et al., 2012).The results of red blood cell count, hemoglobin, and hematocrit are related because they each measure aspects of red blood cells (Tefferi, 2001).

There is a limited studies on platelet count at high altitude with conflicting results. For instance, a fall in platelet counts was observed on ascent to high altitude according to some studies (Gray et al., 1975; Chatterji et al., 1982; Al-Sweedan and Alhaj, 2012). No statistically significant differences were found among the groups regarding the platelet counts between 2000 m altitude and sea level, while the mean platelet volumes were significantly higher in patients living in high altitude ($P = 0.001$) (Alper et al., 2009). Additionally, High-altitude exposure decreased the platelet count, and shortened the platelet function by approximately 20% indicating increased platelet aggregation. Exposure to high altitude activates platelets, which leads to platelet aggregation, platelet consumption, and decreased platelet count (Sharma, 1981; Lehmann et al., 2006).

Previous studies demonstrated the changes in CBC parameters in highlanders, but there is no sufficient evaluation to the effect of living below sea level. This study tends to evaluate the effect of living below sea level on blood count parameters.

There are few researches on reference ranges for blood parameters in school age children. It was stated that median hemoglobin and red blood cell count values for girls and boys rose together with increasing age up to 12 years, but then differed. Girls had a higher platelet count than boys. Mean platelet volume rose with age and was inversely related to the platelet count. Total leucocyte count declines with age (Taylor et al., 1997).

2.2. Significance and exigency of CBC in diagnostic process

CBC has multiple clinical applications and it is usually performed to investigate diseases including anemia which is the most frequent hematological disorder during childhood (Saxena et al., 2007). Many of medical conditions which secondarily influence the blood and bone marrow involving infections, inflammation, coagulopathies, neoplasms, and toxic substances exposure can be evaluated by CBC (George-Gay and Parker, 2003). It is necessary for both clinician and medical laboratory scientist to understand CBC test for a full usefulness and appropriate diagnosis. Understanding CBC in its strength, limitations, and indications by the clinician will serve as an effective tool for avoiding more unnecessary tests and more costly tests for their patients (Aljabali, 2011). CBC is an effective tool to obtain medical information about human body. It is in every clinician's interest to have good understanding of the specific test basics as well as a structured action plan when confronted with unusual CBC results (Tefferi et al., 2005). Nowadays, CBC with differential WBC counts is one of the most commonly ordered laboratory test where the value of every CBC parameter in the disease investigation process aids in diagnosing, treatment, and follow up hematological disorders in addition to solving other medical situations (Tefferi et al., 2005).

CBC parameters are mostly reported as percentages rather than absolute counts, and due to dynamic changes in CBC , differential WBCs count, and reticulocyte count reports tended to be longer and more complicated. Thus, clinicians might be receiving more data and beyond what they need. These excess data are not beneficial to medical practitioner and may lead to miss-understanding and interpretation of data which may result in error in medical judgment (Sandhaus and Meyer, 2002).

2.3. Physiological Background of CBC

The CBC is a medical laboratory test that measures the circulating blood cells in terms of RBCs, Plts in addition to WBCs and its subtypes (Tefferi et al., 2005). CBC is the main test to evaluate the immune system through measurement of WBCs and its myeloid and lymphoid subtypes, and the oxygen-carrying capacity through the measurement of Hgb, Hct and RBCs indices and Plts. It is expected to find only mature blood cells in the circulation under the normal health conditions (George-Gay and Parker, 2003).

All blood cell lines that originated from the pluripotential stem cell (PSC) during hematopoiesis process can be measured by CBC test (George-Gay and Parker, 2003; McPhee, 2010). Hematopoietic stem cell (HSC) has the ability for both self-renewal and transformation into all other blood cellular components, proliferation and differentiation to all blood cell lines (Dixon, 1997; Proytcheva, 2009).

Bone marrow is the main site of production of all blood cells in adulthood from the PSC which undergoes successive differentiation phases until it becomes mature cells (Dixon, 1997; McPhee, 2010). Hematopoiesis process is complex and it depends on the development of human from the embryonic stage to adulthood. The process is divided into three periods in the embryonic stage and named upon the main site of production. Mesoblastic period is the first one and continues for eight weeks from gestation. The mesoderm of the embryo is the origin of the first stem cell, then tiny blood islands appear in the yolk sac where there is an external cell form the vessels and the hemoblast (first primitive RBCs) is formed from the interior cells (Dixon, 1997; Proytcheva, 2009).

The second period is the hepatic period that takes place in the liver. It starts from the second month until the seventh month of gestation. During this stage, spleen also partially contributes to the formation of the blood cells (Dixon, 1997; Proytcheva, 2009).

In the fourth month, the third period begins in the thymus. In this stage, bone marrow (BM) and lymph nodes become the main sites of blood formation. Bone marrow plays the main role in the formation of all blood cell lines, while thymus and lymph nodes are responsible for the final development and activation of the immature WBCs (Dixon, 1997).

Myeloid and lymphoid stem cells are the source of all WBCs. Basophils, eosinophils, neutrophils and monocytes are considered the mature myeloid cells(McPhee, 2010). The first three types are named granulocytes (Dixon, 1997). Granulocytes obtain this name from the granular contents in their cytoplasm. These granules contain potent biochemical mediators such as histamine, serotonin, and heparin in basophils. Additionally granulocytes possess enzymes capable of destroying pathogens or down regulate the hypersensitivity reactions by neutralizing the histamine as in eosinophils (George-Gay and Parker, 2003).

The other cell types that lack granules in their cytoplasm, monocytes which is the largest of the leukocytes as an example, are considered the cleanup crew of the human body with the macrophages (George-Gay and Parker, 2003). Agranulocytes including the other mature lymphoid cell types (T, B and natural killer cells (NK) (Dixon, 1997).
The major portion of WBCs (about 55%-75%) are neutrophils or Poly Morphonuclear Neutrophils (PMNs) function as defender against bacterial infections. These are present in two pools: the circulating pool and the marginal pool (Dixon, 1997; George-Gay and Parker, 2003). In the absence of infection or inflammation neutrophils life span is about 12 hours in the circulation (Dixon, 1997). Defending against the multicellular parasites and detoxifying, the antigen antibody reactions is the main role of eosinophils which make up about 1% to 4% of the total WBCs counts (Dixon, 1997; George-Gay and Parker, 2003).

The rarest granulocytes in the circulation are the basophils and they constitute about 1% play major role in the hypersensitivity conditions and called mast cells in the tissues (Dixon, 1997). Basophils associated with systemic allergic reactions of unclear mechanism of action (George-Gay and Parker, 2003).

Monocytes are the largest cell type of WBCs (George-Gay and Parker, 2003). They constitute about 2%-8% of the total WBCs and they play main role in cleaning up the microorganisms (Dixon, 1997).When they inter the tissue macrophages and named upon the particular tissue they found in (George-Gay and Parker, 2003). They destroy the pathogen and exhibit a cell surface marker to pass information to the lymphocytes. Lymphocytes then use this marker to find the microorganism and defend against it (George-Gay and Parker, 2003).

The second line of defense in the blood are lymphocytes that form about 25%-45% of total WBCs (Dixon, 1997). There are two major types T and B cells. The former are responsible for the cell mediated immune process and constitute about 80% of the circulating lymphocytes. The B cells which represent about 20% of the circulating lymphocytes are responsible for the humoral immune response in human body and the production of antibodies (Dixon, 1997). Defending the human body against the pathogens is the major function of WBCs, they are considered the major players in responding to infection/inflammation (George-Gay and Parker, 2003). There is a different and unique mechanism of defense used by every type of WBCs (Dixon, 1997). T cells have several subtypes, including regulators and effectors (George-Gay and Parker, 2003).

Initiation or suppression of the immune response is the role of regulator T cells from which they derive their name. Regulator T cells are also classified into two subtypes, T helper cells and T suppressor cells. T helper cells are considered the master trigger of the immune system, they possess the cluster of differentiation 4 (CD4) surface marker. T suppressor cells' function is to inhibit the immune response once the immune system controls the infection (George-Gay and Parker, 2003). Effector T cells have also two subtypes; T toxic cell that possess the cluster of differentiation 8 (CD8) and act to destroy the cancer cells and virally infected cells. And memory cells that perpetuate long lasting immunity against certain microorganism (George-Gay and Parker, 2003). B cells constitute the body's main humoral immunity crew. Upon its activation, it transforms into plasma cells which produce antibodies (Dixon, 1997).

Natural Killer (NK) cells do not have T or B markers. Despite the fact that they are non-specific cells, they are very effective against cancer and virally infected cells (George-Gay and Parker, 2003).

Red Blood Cells (RBCs) are produced through the erythropoiesis process in the bone marrow, which is stimulated by an oxygen-sensing system (See Figure 3.) located in the kidney, and also involves the erythropoietin hormone (George-Gay and Parker, 2003). They do not have nuclei at maturity, their nuclei are extruded during the final phase of the development. The presence of RBC with nuclei in the peripheral blood smear suggests an underlying disease (McPhee, 2010).

The results of red blood cell count, hemoglobin, and hematocrit are related because each one of them measures aspects of red blood cells. If the measures in these three areas are lower than normal, the patient have anemia. Anemia causes fatigue and weakness. Anemia has many causes including low levels of certain vitamins or iron, blood loss, or an underlying condition. A red blood cell counts that's higher than normal (erythrocytosis), or high hemoglobin or hematocrit levels, could point to an underlying medical condition such as Polycythemia Vera (PV) or heart disease (Tefferi, 2001).

RBCs are small and flexible, and their main function is to supply the living tissues with oxygen that picks up in the lungs pole, and remove the generated carbon dioxide waste from the cells to lungs for excretion (Dixon, 1997; George-Gay and Parker, 2003).

Bone marrow is the place where RBCs are produced by RBCs progenitors. This process is called erythropoiesis. During erythropoiesis the progenitors go through a series of phases that lead to production of mature RBCs (Dixon, 1997; Messinezy and Pearson 1997; Letter. 2001). RBCs are considered as Hgb sacs, they cannot split as they do not have nuclei, and their lifespan is about 120 days in peripheral blood (George-Gay and Parker, 2003).

There are many factors required in the metabolism of RBCs such as amino acids, vitamin B12 and folic acid where all is basically involved in cell development and DNA synthesis (Dixon, 1997; George-Gay and Parker, 2003). Globin chain synthesis takes place on RBC-specific cytoplasmic ribosomes that are triggered from the inheritance of various structural genes (Figure 2.1) (Harmening, 2006).

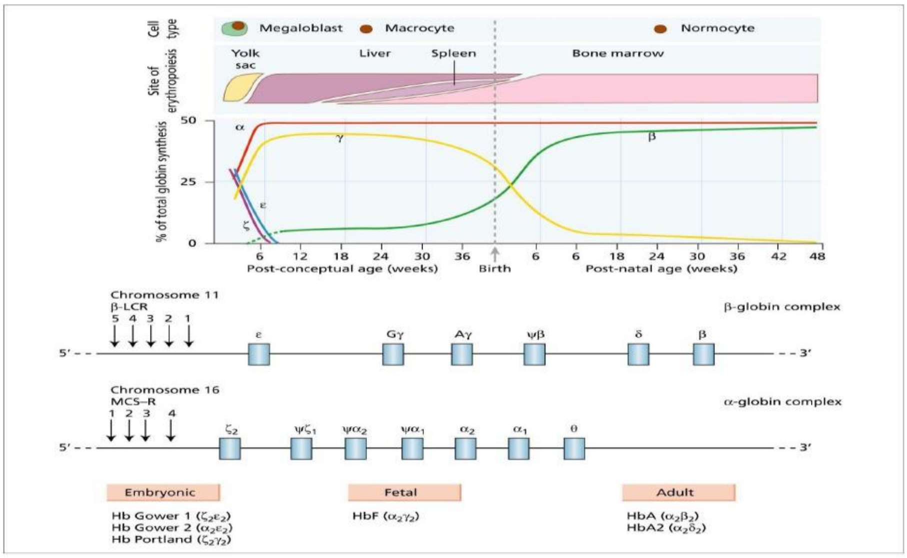

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Figure 2.1*:* The genetic control of hemoglobin synthesis (Hoffbrand et al., 2011).

Hgb synthesis requires four iron atoms for each Hgb molecule (Dixon, 1997; George-Gay and Parker, 2003). Production of RBCs is a highly complex process which includes multi biochemical and metabolic pathways, heme and Hgb synthesis, Acquisition of iron, amino acids (A.A), vitamins, and growth factors in the bone marrow , in addition to the synthesis of alpha and beta globin chains that build up the Hgb (Dixon, 1997). In a CBC test Hgb is the major indicator for anemia or polycythemia (Tefferi et al., 2005). Hgb molecule is a heme-portion complex of two pairs of similar polypeptide chains (Figure 2.2).

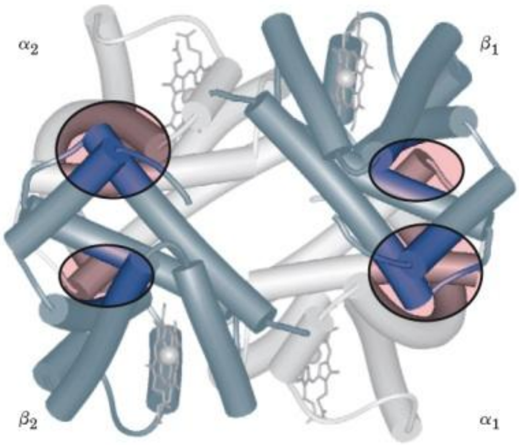

Figure 2.2: Dominant interactions between hemoglobin subunits (Nelson, 2008)**.**

In this representation, α subunits are light and β subunits are dark. The strongest subunit interactions (highlighted) occur between unlike subunits. When oxygen binds, the $\alpha_1\beta_1$ contact changes little, but there is a large change at the $\alpha_1\beta_2$ contact, with several ion pairs broken (Altschuler and Kast, 2005).

Amino acids, iron, and vitamin B6 are requirements for Hgb synthesis (Dixon, 1997; Irwin and Kirchner, 2001). Two alpha and two beta globin chains form the globin protein in human adults while iron and vitamin B6 are involved in the formation of heme which gives the blood its color (Dixon, 1997; George-Gay and Parker, 2003). Iron in the ferric state (Fe^{+3}) is delivered to the membrane of RBC precursors by the protein vehicles transferrin. It proceeds to the mitochondria where it is reduced to ferrous (Fe^{+2}) state for incorporation with the protoporphyrin ring to form heme. This process is influenced by Epo, it requires vitamin B6. The cytoplasm is the place in which each synthesized globin chain binds with heme (ferroprotoporphyrin IX) to form hemoglobin, which is basically formed of two alpha chains, two beta chains, and four heme groups (Harmening, 2006).

The different beta-globin genes arose by a duplication of an ancestral gene, most likely as a result of an "unequal crossover" during meiotic recombination in a developing germ cell, and from random beneficial mutations over evolutionary time (Lodish et al., 2008).

Hct represents the percentage of the packed RBCs volume to the total whole blood volume. Hct is a parameter that is calculated in most automated blood cell counters by multiplying Mean Corpuscular Volume (MCV), with RBCs and dividing the result by ten (George-Gay and Parker, 2003). Hct is an indirect measure of oxygen carrying capacity in blood while Hgb is considered a direct measure of oxygen carrying capacity and seems more sensitive in diagnosing anemia but, still not a gold standard. Additionally Hct is a main factor that determines blood viscosity (Quinto et al., 2006). Mean Corpuscular Hemoglobin Concentration (MCHC) parameter, which is one of the RBCs indices, expresses the relationship between both Hgb and Hct parameters (Quinto et al., 2006).

Thrombocytes or Platelets (Plts) are the smallest cells that found in the blood circulation with a life span from nine to twelve days (George-Gay and Parker, 2003). Like an erythrocyte, thrombocyte lacks the nucleus but it is derived from the myeloid stem cell through a series of developing stages (George-Gay and Parker, 2003). Circulation contains about 70% of the Plts while spleen have the other part (George-Gay and Parker, 2003). Plts have two main functions: first, one is forming a plug along with coagulation factors to close the bleeding site. Second role is to aid in vascular integrity (Dixon, 1997).

2.4. Clinical utility, interpretation, and evaluation of CBC

Nowadays, it is possible to perform the entire CBC with few sampling errors in a single instrument during one minute while automated counting was done for the first time in 1960s only for WBCs and RBCs (Dixon, 1997; Matsuno and Ishizuka, 1998). Though CBC is typically not a definitive diagnostic test, it has multiple clinical applications in practice. Clinicians use it as a key to find any abnormality. Blood is one of the most responsive tissues in our bodies to any physiochemical changes in human body, which signifies that blood can reflect the inner status of our bodies at any condition and it is rich with ~~a~~ valuable medical information. CBC test includes up to eighteen parameters in some instruments.

Since the CBC is a panel of tests that help in diagnosis of any hematological or non-hematological disorder, the clinician should use it as a primary investigation to evaluate the human body state. CBC is usually used as a screening test for asymptomatic individuals (George-Gay and Parker, 2003).

It is essential to evaluate every hematologic parameter in the CBC with consideration of other parameters. A non-hematologist should address some but not all CBC abnormalities (Tefferi et al., 2005). We have tracked in this study the nine basic components of CBC which are WBCs, RBCs, Plts, Hgb, Hct, RDW, red blood cell indices, MCV, MCH and MCHC. During the evaluation of CBC parameters, it is essential to rule out potential diseases such as any abnormal increase or decrease in the value of a given parameter that could indicate the presence of a specific disease.

Evaluation of WBCs or the leukocytes begins with the examination of the total WBCs count followed by scrutinizing of the differential WBCs counts (Letter. 2001; Tefferi et al., 2005). Increase in the WBCs count above 11,000/uL is termed leukocytosis, which appear in infections, inflammations, and in cancers or marrow disorders (George-Gay and Parker, 2003; Tefferi et al., 2005). In leukemia, there is a severe increase in the total WBCs count above 100,000 /uL, which may affect the blood circulation by increasing the blood viscosity and result in Venous Thromboembolism (VTE) (George-Gay and Parker, 2003). Leucopenia is the decrease in total WBCs count below 4,500/uL. Most commonly, it is manifested as neutropenia or lymphopenia, which may indicate bone marrow failure unless it due to immuno suppressive therapy (George-Gay and Parker, 2003; Tefferi et al., 2005).

Evaluation of both subtypes of WBCs granulocytes and agranulocytes is important. Neutrophilia condition is the increase in neutrophils count and indicates bacterial infection, or Chronic Myelocytic Leukemia (CML) in the case of sever elevation. One of the principles in the differentiation of Neutrophilia is to distinguish between the type of elevation, where there is an elevation in the segmented neutrophils when there is a shift to right. This appears in cases such as burns, hemorrhage or injuries. Shift to left means that there is an elevation in the band neutrophils, which is an indicator of releasing immature cells into the circulation under the stress of acute bacterial infection or some cancer. Eosinophils are the second type of granulocytes, and their increase which termed Eosinophilia is an indicator to multicellular parasitic infection. Basophiles are the third type of granulocytes, they increase in allergic reactions, and the condition is called Basophilia (George-Gay and Parker, 2003; Tefferi et al., 2005).

Lymphocytosis refers to an elevation in Lymphocytes counts occurs in the case of viral infections such as Cytomegalovirus (CMV), mumps and acute leukemia. While the increase in monocytes is called Monocytosis which is seen in certain malignancies in addition to chronic infections (Tefferi et al., 2005).

The evaluation of the RBCs, Hgb, Hct and the red blood cells indices is also highly informative in the CBC test. RBCs counts evaluate the oxygen-carrying capacity of blood, and it is also critical to assess the bone marrow function especially in marrow failure states. Erythrocytosis is the increase in the RBCs counts which may be observed in many situations such as Polycythemia Vera or dehydration. This increase in RBCs count is related to Hgb and Hct (George-Gay and Parker, 2003). Measurement of Hgb and Hct in medical practice represents the initial methods for iron deficiency screening, but additional laboratory tests are needed (Beutler et al., 2003). Hgb is a direct measure of anemia while Hct is an indirect parameter for evaluation of anemia (George-Gay and Parker, 2003; Tefferi et al., 2005, Carneiro et al., 2007). Red cell indices represents a basic criterion for classification of many types of anemia. MCV is touchstone which allows placement of anemia into one of the standard classification of macrocytic, normocytic or microcytic anemia to narrow down the diagnosis of many types of anemia (Irwin and Kirchner, 2001). MCV describes the RBC by size or volume which is the volume in femto-liters of the average circulating RBCs (Godon et al., 2012; Salisbury et al., 2012).

Usually, MCV lower than 75 fL is correlated with thalassemia which can predict the disease by differentiating the type of anemia from thalassemia (Muncie and Campbell, 2009). Mean Corpuscular Hemoglobin (MCH) measures the average weight of Hgb in an RBC and is correlated to MCV. They elevate and fall together, which is an evidence on that cell counter is working properly (George-Gay and Parker, 2003).While Mean Corpuscular Hemoglobin Concentration (MCHC) is a measure of the average concentration of Hgb in an RBC per unit volume, and is considered a marker for some diseases, spherocytosis as an example. Spherocytosis is a common inherited red cell membrane disorder resulting from mutation in gene encoding various red cell membrane and skeletal proteins (Da Costa et al., 2013). RBCs indices are useful in evaluation iron status, and assessing the need for iron supplementation during erythropoietin treatment in the case of anemia of renal failure (Goodnough et al., 2000).

Platelets (Plts) or thrombocytes counts are a valuable parameter in CBC test. When there is a decrease in the PLts counts which is a case known by thrombocytopenia, CBC test may reveal the need for blood transfusion prior to surgical intervention, or even constrain the clinician to cancel a main or alternative surgery for that patient (George-Gay and Parker, 2003). Other causes of reduced PLts counts such as drug induced or spurious thrombocytopenia which may result from Ethylen-Diamin Tetra Acetic acid (EDTA)-induced aggregation and to platelet satellitism around polymorphs (Tefferi et al., 2005; Zandecki et al., 2007; Tessier-Marteau et al., 2010). Increase in PLts counts over than 1,000,000/uL in the circulation which is known as thrombocytosis could be found as a result of physical stress, infection or in myeloproliferative disorders and cancers such as hepatocellular carcinoma (George-Gay and Parker, 2003; Carr and Guerra, 2013).

RDW, which stands for Red Distribution Width, represents the coefficient of variation of MCV in terms of the degree of size variation or anisocytosis in the erythrocyte population. Red cell distribution width is a new routine parameter in fully automated hematology analyzers that can give an idea of early iron deficiency before other tests. It gives an idea of red cell size variation which is the earliest morphologic changes in iron deficiency anemia. In pre-latent and latent stage of iron deficiency MCV are normal. Whereas in latent stages, RDW would be expected to increase because of a microcytic population of cells appears in the blood. Hence, Iron deficiency anemia without other complicating disease could be screened out early by increased RDW when RBC indices are normal (Sandhaus and Meyer, 2002; Sultana et al., 2013). RDW is also important in differentiating iron deficiency anemia and sideroblastic anemia from thalassemia, as RDW is elevated in these conditions more than thalassemia (James, 2007; Muncie and Campbell, 2009).

There is a continuous updating in hematology. In an unexplained iron deficiency anemia, when Hgb is less than 11 g/dL, the Hgb and Hct are the most useful hematologic indices in significant pathologic endoscopy, while MCV is not (Schizas et al., 2007). It was also observed that men with Hct and Hgb in the upper 20th percentile are associated with increased risk for Venous Thrombo Embolism (VTE) compared to men in the lower 40th percentile, while MCV was not associated with VTE (Braekkan et al., 2010) . Mean Platelets Volume (MPV) is increased in acute myocardial infarction. It has been identified as an independent risk factor for future myocardial infarction and stroke. Besides, an increasing MPV was identified as a predictor for VTE, in particular VTE of unprovoked origin (Braekka et al., 2010). The increased Hct may result in alteration in blood viscosity, leading to slow blood flow and then increased platelets adhesiveness (Braekkan et al., 2010). Alpha thalassemia trait at birth can be predicted by low MCV and MCH parameters in neonates (Hall and Lundgrin, 1987) which may provide a practical and cost effective test in screening neonates for alpha thalassemia when MCV is less than 90 fL.

2.5. The Physiologic Basis of High-Altitude Hypoxia

Altitude is the vertical distance above sea level. Medium altitude is located between 1829 and 3048 m above sea level. High altitudes are higher than 3048 m above sea level. As altitude increases, the barometric pressure decreases and oxygen partial pressures become lower, reducing maximal oxygen uptake. In addition, temperature drops at a rate of 1°C for every 150 m. Maximal oxygen uptake decreases as altitude increases above 1600 m. Consequently, both medium and high altitude can adversely affect performance in endurance activities, particularly in those who normally live at sea level (Kent, 2013).

Inner altitude : it is how the alveolar PO_2 changes with barometric pressure while body starts to sense the change in oxygen level and responds by increasing the breathing rate, which occurs at around 5000 Ft (1500 meter), it is called physiologic altitude (Gippenreiter and West, 1996).

As we gain more elevation we notice that there is a decrease in the atmospheric pressure. Actually, the oxygen percent is the same at all altitudes (21%) but, it is 21% with a smaller number of O_2 molecules as we go higher. At sea level, the barometric pressure is 760 mmHg, and at about 3000 meter, it is 534 mmHg. Breathing the air at this altitude is equivalent to breathing air with only 15% oxygen at sea level, instead for 21%. At 4200 meter, the air contains 43% less oxygen than that at sea level (Table 2.1). The volume of air we breathe into our lungs at high altitude contains less oxygen molecules in each breath, because of the reduced air pressure (Pendse and Singh, 2005). However, the hypoxic threshold depends on the ratio of ATP demand to aerobic capacity (Connett et al., 1990). Figure 2.3 represents the relationship among altitude, barometric pressure, and inspired PO_2 (West, 2004).

Hypoxia of cells are a basic mechanism of injury in the critically ill. A human response to hypoxia that occurs from hypobaria creates the need to study the fields of high-altitude medicine and physiology. A new model suggests that the physiological and pathophysiological responses to special environmental challenges (for example, hypobaric hypoxia, hyperbaria, microgravity, cold, and heat) may be similar to responses seen in critical illness (Grocott et al., 2007). It is not unusual to assimilate exposure to hypoxic condition to exercise, where alterations in active muscle glucose uptake with training determine changes in the whole body glucose kinetics (Bergman et al., 1999).

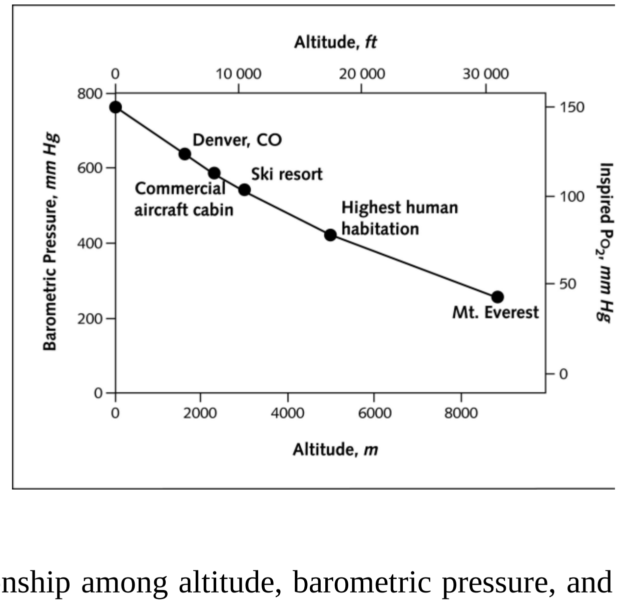

Figure 2.3*:* Relationship among altitude, barometric pressure, and inspired PO_2 (West, 2004)**.**

Table 2.1:Barometric Pressure and Inspired PO_2 at Various Altitudes from (West, 2004; Palestinian Meteorology Center, 2013).

Altitude, meter	**Barometric pressure, mmHg**	**Inspired PO_2, mmHg (% of sea level)**
-260 (Jericho)	**786**	**155 (104)**
0 (0) (sea level)	**760**	**149 (100)**
1000 (near Ramallah)	**649**	**132 (89)**
2000	**604**	**117 (79)**
3000	**537**	**103 (69)**
4000	**475**	**90 (60)**
5000	**420**	**78 (52)**
8848	**253**	**43 (29)**

2.6. Sensing Hypoxia

In addition to the activation of the Erythropoietin-Erythropoietin receptor pathway (Epo-EpoR), there are several of physiological responses induced by tissue hypoxia. The response of erythropoietin to hypoxia differs among individuals. Responses are parallel and include the stimulation of new blood vessels by vascular endothelial growth factor (VEGF) with other metabolic changes (e.g. glycolytic pathway enzymes) which help to resume energy production despite insufficient oxygen delivery. It has been proved that the most important mediator involved in these cellular response is a transcription factor called hypoxia-inducible factor (HIF) which activates the genes that influence the adaptation responses to hypoxia including those encoding Epo, glycolytic pathway enzymes Transferrin receptors (TfR) and VEGF (Figure 2.4). Dimerization of the two subunits of HIF (alpha and beta) under hypoxic conditions triggers series of processes to restore the oxygenation state where hypoxia elevate the level of HIF-alpha subunit by increasing protein stability. Ferrous iron prolyl hydroxylase is the oxygen sensor that needs molecular oxygen as a co-substrate to hydroxylate specific proline residue in the alpha subunits of HIF. When hydroxylated HIF-alpha subunits become targets for ubiqutination by vHL protein and then for proteasomal degradation (Hoffbrand et al., 2011).

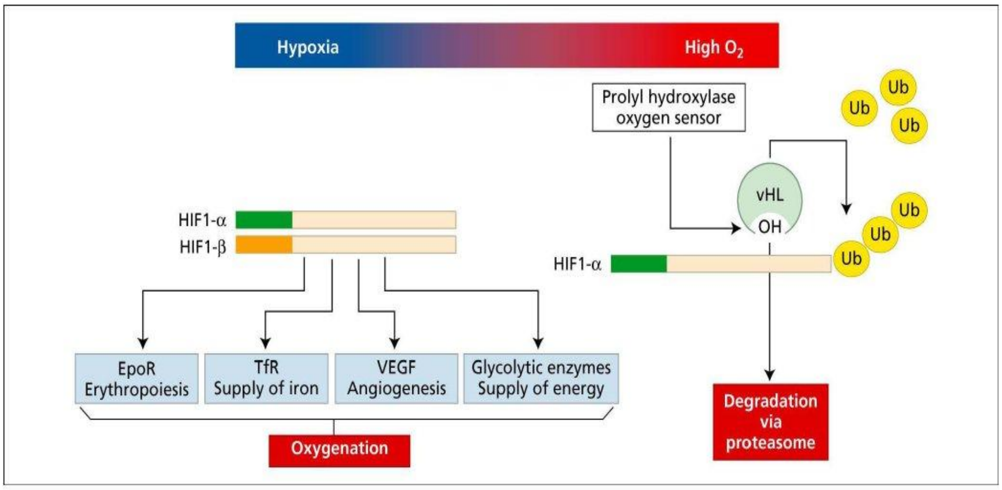

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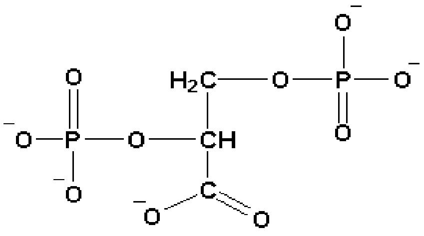
Figure 2.4: The Oxygen Sensing System. Ub, ubiquitination; vHL, von-Hippel Lindau protein.

2.7. The 2, 3-DPG as a main regulator of Hemoglobin –O2 binding

The function of Hgb is adjusted by the interaction with 2,3-diphosphoglycerate (DPG)/ BPG (figure 2.5), which represents an example of heterotropic allosteric modulation.



2,3-Bisphosphoglycerate

Figure 2.5: 2,3-DPG structure (Nelson, 2008).

Erythrocytes contain relatively high concentrations of DPG. DPG function is to reduce the affinity of Hgb for oxygen, where there is a reverse relationship between the binding of oxygen and the binding of DPG. It binds Hgb at a site adjacent to the site of oxygen binding and regulates the O_2 binding affinity of Hgb according to the pulmonary PO_2 level. At high altitude DPG is very important in the adaptation processes because of the low PO_2 levels. At sea level for healthy individual, the binding of O_2 to Hgb is regulated in which the amount of O_2 delivered to tissues is nearly 40% of the maximum that could be transferred by the blood. When a man suddenly moves to 4500 m altitude from sea level, the delivery of O_2 to tissues is reduced. After few hours, the DPG concentration in his blood begins to elevate, causing decrease in Hgb-Oxygen affinity (Harmening, 2006; Nelson, 2008). This change in DPG level has a small effect on O_2 binding in lungs and great effect on O_2 release in tissues (Figure 2.6). This enhanced release occurs regardless of pH or blood arterial oxygen level (Harmening, 2006). The situation is reversed when the person returns to sea level (Lenfant et al., 1968; Nelson, 2008).

2.8. Erythropoietin at High Altitudes

Erythropoietin hormone is produced by peritubular complex of the kidney. It is approximately 31,000 daltons (d) with plasma half-life between 6 and 9 hours. It may be a sialic acid-containing glycoprotein. The production of Epo increases when there is a decrease hemoglobin level, a hemoglobin structural problem in which oxygen is not adequately released, or low ambient oxygen tension at high altitude (Demopoulos et al., 1965; Harmening, 2006). There is little or no Erythropoietin (Epo) $_m$RNA detected in the kidneys under normoxic conditions, while hypoxia results in accumulation of Epo within 30 minutes and levels can elevate to 200 fold over its baseline. The binding of Epo to its receptors (EpoR) results in signal transduction to the nucleus which leads to constitutive erythropoiesis. When tissue oxygenation is low, the Epo level rises stimulating RBC synthesis, and inhibiting the apoptosis of RBC precursors. Epo induces dimerization of EpoR, triggering auto-phosphorylation and activation of (JAK2) Janus family of protein tyrosine kinases, which is essential for erythropoiesis. Epo response to hypoxia is modified by altitude acclimatization. Higher 2,3-DPG levels could partly explain the decreased sensitivity of the Epo response to hypoxia. Altitude acclimatization modifies the control of erythropoiesis not only at sea level, but also during a subsequent hypoxia (Savourey et al., 2004). However, Epo production, during altitude training, needs to be evaluated in larger future studies (Hoffbrand et al., 2011; Son et al., 2012).

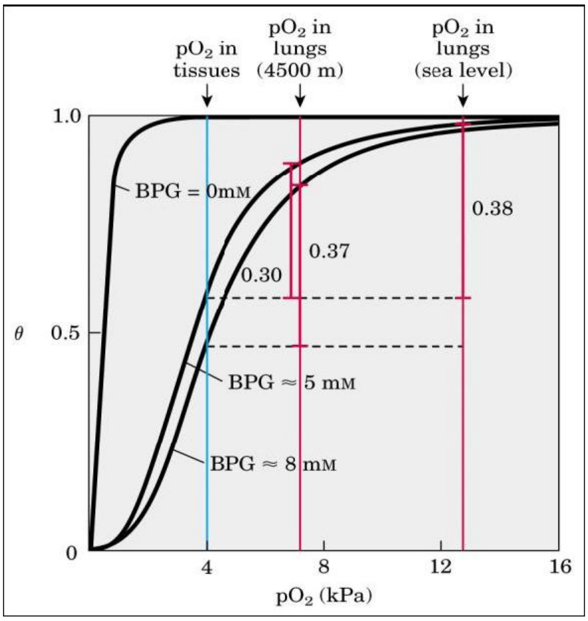


Figure 2.6: Effect of DPG Hgb-O_2 dissociation curve (Nelson, 2008).

At sea level, Hgb, to some extent, is saturated with O_2 in the lungs, but just over 60% saturated in tissues. Hence, the O_2% that released in the tissues is about 38% of the maximum that can be transferred by blood. At high altitudes O_2 delivery is plummet by about 25%-30% of maximum. An increase in DPG concentration (Goodford et al., 1977; Quatrini et al., 1993) decreases the affinity of Hgb to $O_{2,}$ so approximately 37% of what can be carried is restored again to body tissues (Nelson, 2008).

2.9. Hepcidin and Hypoxia

Hepcidin is a small peptide (25 amino acids) with several isoforms and it is released from a large pre-pro-peptide of 84 amino acids. It is a product of the HAMP gene on the long arm of chromosome 19. It is mainly expressed in liver and functions to regulate iron hemostasis by binding to ferroportin inhibiting iron absorption in intestines, iron release from macrophages and iron transport across the placenta (Figure 2.7) (Beutler et al., 2003). Hepcidin is regulated by many factors. High plasma iron and inflammation stimulate Hepcidin synthesis. Conversely, low plasma iron, increased rates of erythropoiesis and hypoxia (including hypobaric hypoxia at high altitude) inhibit its production (Figure 2.8). Therefore, iron absorption is increased at high altitude (Hoffbrand et al., 2011).

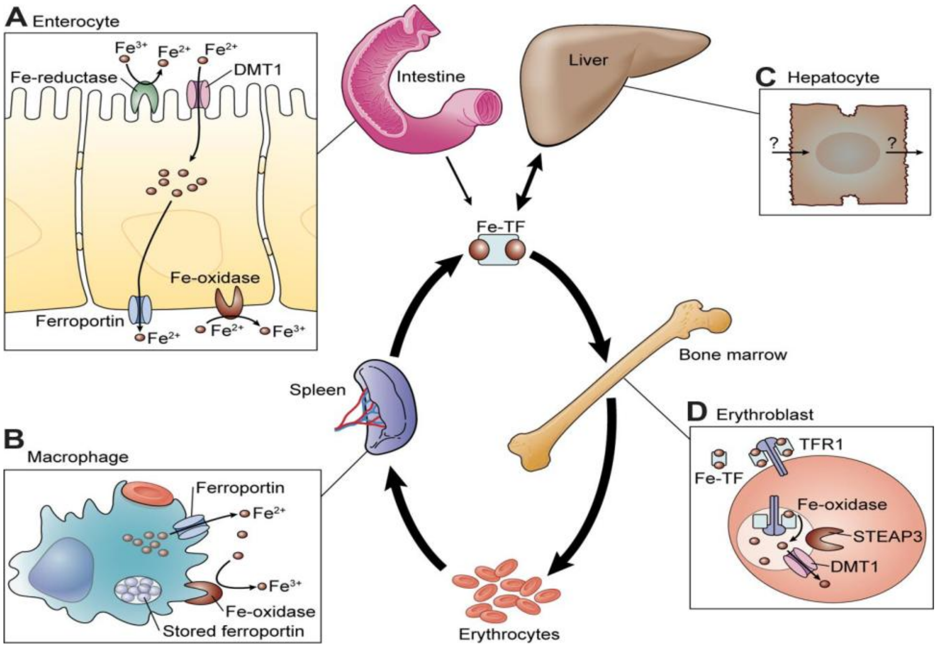
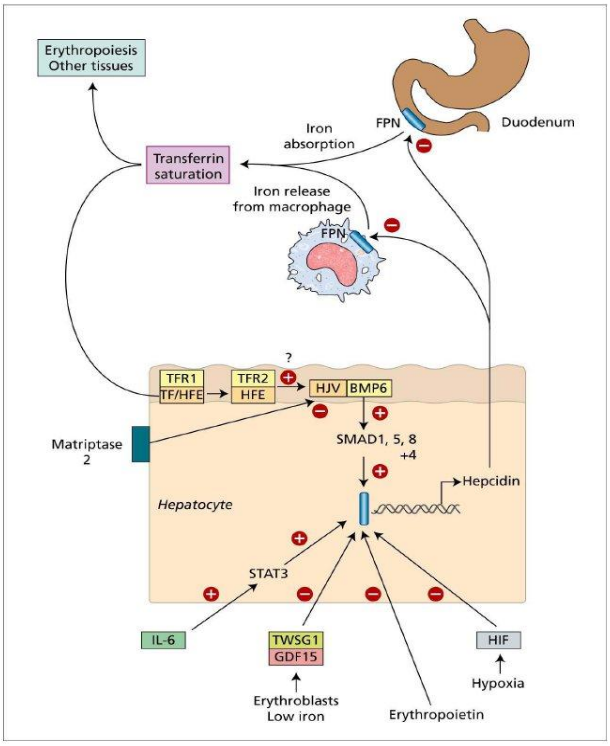


Figure 2.7: Hepcidin regulates iron hemostasis by binding to ferroportin iron transporter inhibiting iron absorption in intestines and iron release from macrophages (Weiss and Goodnough, 2005).



From: Victor Hoffbrand *et al.* (ed.) *Postgraduate Haematology* 6th edn © 2011 Blackwell Publishing Ltd.

Figure 2.8: Hepcidin regulation (adopted from Hoffbrand et al., 2011).

2.10. High Altitude and oxidative stress

Mammalian cells are capable of adapting to chronic or repeated stress by regulating protective systems such as their proteasomal proteolytic capacity to remove oxidized proteins**.** Repeated stress adaptation can result in significant extension of adaptive responses. Repeated stress must occur at sufficiently long intervals for adaptation to be successful, and the levels of both repeated and chronic stress must be lower than it is optimal for adaptation to acute stress. Although both repeated and chronic stress can be tolerated, they may result in a shorter life, however, high-altitude trekking is associated with increased blood oxidative stress (Martinez et al., 2005; Dosek et al., 2007; Miller et al., 2013). During chronic exposure to high altitude, humans could exhibit an effective adaptive response to oxidative stress by accelerating the antioxidant defense. Hence, strengthening the antioxidant defense could be an effective strategy to get rid of free-radical-mediated pathophysiological alterations and enhance acclimatization to oxidative stress (Vij et al., 2005). It Also decreases in animals fertility at a high altitude may due to oxidative stress with hypoxia on anatomical and functional corpus luteum (Parraguez et al., 2013).

2.11. Biochemical changes at high altitude

Pre analytical variables, which may affect laboratory test values, are classified into two main categories: those that are controllable and those that are not. Non controllable variables include environmental factors such as altitude , ambient temperature, and place of residence. Erythrocytes demonstrate increase in 2,3-DPG level at high altitude. The increased erythrocyte concentration leads to an increased turnover of nucleoproteins and excretion of uric acid. The increase in uric acid levels appears to be caused by increased urate generation secondary to systemic hypoxia, although a relative impairment in renal excretion also may contribute to it (Jefferson et al., 2004).

The fasting basal level of growth hormone concentration is high in individuals living at high elevations (Carl, 2001).

There are three possible catabolic fates of the pyruvate formed in glycolysis, one of them is reduction to lactate via lactic acid fermentation. When vigorously contracting skeletal muscle must function under low Oxygen conditions (hypoxia), NADH cannot be re-oxidized to NAD^+, but NAD^+ is needed as an electron acceptor for the next oxidation of pyruvate. Under these circumstances pyruvate is reduced to lactate, accepting electron from NADH and, thus, regenerating the NAD^+ required for glycolysis to be resumed (Nelson, 2008). Blood lactate concentration during exercise decreases after acclimatization to high altitude (Bender et al., 1989), which is due to a reduction in anaerobic glycolysis (Green et al., 1989). In addition to Hct and Hgb, glucose, LDH, Triglycerides, and Insulin levels showed that there are significant differences pre-exercise due to the area (altitude) variation among soccer players in Palestine (Albahsh, 2001).

Hormones (thyroid, catecholamines, and cortisol), iron status (serum iron, ferritin, transferrin, and haptoglobin) and renal function (creatinine, renal, osmolar, and free-water clearances) do not significantly vary except for lower thyroid stimulating hormone at sea level. Altitude acclimatization modifies the control of erythropoiesis not only at sea level, but also during a subsequent hypoxia (Savourey et al., 2004).

Testosterone is a hormone that regulates erythropoiesis and ventilation, it could be associated to the processes of acclimatization and adaptation to high altitude. Excessive erythrocytosis, which leads to chronic mountain sickness, is caused by low arterial oxygen saturation, ventilatory inefficiency, and reduced ventilatory response to hypoxia. Testosterone increases during acute exposure to high altitude and also in natives at high altitude with excessive erythrocytosis. Results of current research allow to conclude that increase in serum testosterone and hemoglobin is adequate for acclimatization, as they improve oxygen transport, but not for high altitude adaptation, since high serum testosterone levels are associated to excessive erythrocytosis (Gonzales, 2011).

2.12. Physiological changes at high altitude

Most people working or living at an altitude of 4000 m experience an increased number of arithmetic errors, reduced attention span, and increased mental fatigue. The molecular and cellular mechanisms responsible for impaired mental performance during hypoxia are poorly understood (West, 2004). Human body must adjust to the lower oxygen levels, and this process of adjustment is called acclimatization. Many changes occur in human body during acclimatization. One of the first things that could be noticed is that faster and deeper breath to take in more oxygen. Therefore, man might feel short of breath for the first 2-3 days, especially with physical activity. Some shortness of breath with exercise is normal. Heart rate also increases to supply more oxygenated blood to the tissues, and this might be noticeable during the first few days. After that, it goes down towards a more normal rate. Increased urination is a response to changes in body's acid/base balance and helps in the acclimatization process. This is usually noticeable on the second day. Some people experience mild swelling in their hands, feet, and face, which is not serious (Hackett, 2013).

Trouble sleeping is usually common at high altitude as the low oxygen directly affects the sleep center of the brain. Frequent awakenings, the main problems are light sleep and less total time of sleep, and these usually improve with acclimatization after a few nights. Some persons, however, are expected to have some troubles in sleeping despite acclimatization. (Hackett, 2013)

Chapter Three: Methods and Materials

The aim behind this chapter is to provide an overview of the methodology followed in this study, namely research questions and hypothesis, setting and participants, materials, and data analysis.

3.1. Research questions and hypothesis

Based on the objectives stated above, the present study sets out to seek answers to the following research questions :

1. What is the CBC of those who live below sea level?
2. Is there any difference between the CBC parameters of those living below sea level and those living above sea level?
3. Is this difference (if present between the two groups) resulted from the altitude difference or related to other causes?
4. To what extent can this altitude affect the CBC parameters?
5. Do we need to establish reference range for those living in Jericho if differing from those living in Ramallah?

In order to attain the above objectives, and with these research questions in mind, the following hypothesis is derived in the light of the literature review:

Hypothesis: Oxygen partial pressure (PO_2) in the air is the main factor that influence Erythropoietin (Epo), Erythropoiesis (Red Blood Cells Production), and Hemoglobin (Hgb) synthesis. The regulation of intensity of erythropoiesis depends on the level of PO_2 in the kidneys, in addition to an inverse relationship between PO_2 and erythropoiesis. Jericho is located 300 m below sea level with PO_2 155 mmHg. Ramallah city is located 900 m above sea level with 132 mmHg. This difference in PO_2 availability does it lead to differences in CBC parameters?

3.2. Setting and participants

This study was designed to evaluate the effect of living below sea level on blood parameters by comparing CBC parameters of people living below and above sea level. It is also targeting to assess if there is a need for a new hemogram reference range for those living below sea level.

Four secondary schools were chosen for the study: Two in Jericho and two in Ramallah. *Hisham Bin Abd-EL-Malik Boys School* and *Ali Bin Abee Talib Boys School* in Jericho, and *Ramallah Secondary Boys School* and *AL-Bireh New Secondary Boys School* in Ramallah. Eleventh and twelfth grade male students were targeted for this study, where the age of students ranged from 16 to 19 years. Three hundred-twenty students were chosen as a convenient random sample from a total of 1201 students; 814 from Ramallah and 387 from Jericho. Any subject with a CBC parameter beyond mean ± 3 Standard Deviations (SD) was excluded (Natrella, 1963; Osborne, 2004) and accordingly, 23 of them were excluded (Annex IA and IB). Table 3.1 describes the distribution of participants among the chosen schools. Evaluating and verifying applied reference ranges requires at least 120 reference individuals (Emerk, 2008; Gary , 2008). Six months of residency in the place was a criterion for selecting the participants.

Table 3.1: Sample distribution according to residency place and class.

		Place					
		Jericho		**Ramallah**		**Total**	
		Number of students	**%**	**Number of students**	**%**	**Number of students**	**%**
Class	**11**	**81**	**55.48%**	**89**	**58.95%**	**170**	**57.5%**
	12	**65**	**44.52%**	**62**	**41.05%**	**127**	**42.5%**
	Total	**146**	**100%**	**151**	**100%**	**297**	**100%**

The study was conducted in February 2013. Upon pre-coordination with the heads of schools, two visits were scheduled to those schools by the researcher before sample collection in order to identify the logistic hurdles and to plan how to overcome them.

3.2.1. Sample collection

Samples of Jericho schools were collected and tested firstly, whereas the samples of Ramallah schools were collected and tested in the second round. The site of vein puncture was swabbed with 70% isopropanol (Ruth, 2012). 3 mL venous blood was collected from each participant in K_3EDTA as an anticoagulant according to the guidelines of ICSH (1982). A rack was used to hold the blood samples in an upright position. A 20 liter refrigerator containing ice bags and digital thermometer was used for transporting the samples to the laboratory for testing.

The time between sample collection and testing was about 5.30 and 8 hours. The temperature range in the refrigerator during transportation of Jericho samples was between 3.1 Celsius and 7.1 Celsius, while it was between 3.0 Celsius and 6.6 Celsius during transportation of Ramallah samples.

3.3. Questionnaire

The aim behind using the questionnaire is due to different reasons. Questionnaire has many advantages: collecting a huge number of data in a short time, not very expensive, and data processing can be very fast, mainly by using some computer’s software.

The study questionnaire shown in Annex II was administered in January 2013. Part one included demographic and socioeconomic information about the participant such as, place, and date of birth. While part two included twenty three questions focusing on life style and anthropometric measures. As it was mentioned above, four secondary schools were chosen to conduct the study, two in Jericho city and two in Ramallah city. Every school has been visited before sample collection and questionnaires were distributed in the school.

The questionnaires were answered by the targeted students in their class rooms under the supervision of the researcher after coordination with the school director and social specialist of each school. They were told that there were no right or wrong answers and their confidentiality is secured, and that their answers would be used for the study only. Besides that, the questionnaire was administered in the Arabic language, as the level of the students in English does not allow them to understand this instrument properly and, therefore, would negatively affect the answers and the results of the study. The respondents were also asked to answer each item honestly based on their own experience. Eleventh and twelfth grade students were targeted during this study, where the age of students ranged from 16 to 19 years.

Three hundred and twenty students agreed to participate in the study: one hundred and sixty two in Ramallah and one hundred and fifty eight students in Jericho. All of those who were qualified and agreed to participate in this study had filled the questionnaire and donated a blood sample after a consent form was signed by the students guardians (Annex IV). Permission by the ministry of education and heads of schools to conduct the study was also obtained (Annex III). The study was approved by the ethical research committee at Al-Quds university.

3.4. Materials

Table (3.2) shows the materials and equipment used in the study.

Table 3.2: Materials used in the study.

Number	Item	Manufacturer
1	Needles, 21 G and sharps disposal containers	BD Microlance
2	Syringes 5 mL	OMG
3	Tourniquet	------------------
4	Gloves	------------------
5	70% isopropyl alcohol swaps	------------------
6	Sterile gauze swaps and alcohol dressings	------------------
7	Racks	------------------
8	Pen, Watch and logbook	------------------
9	10 liter refrigerator and ice pieces	GTN
10	Digital thermometers	------------------
11	Fresh venous whole blood	------------------
12	K_3EDTA tubes	Meus sacco, Italy
13	Hematology control blood (MEK3DN)	Nihon Kohden, USA
14	Automated cell counter (Nihon Kohden-Cell tack alpha,6410).	Nihon Kohden, Japan

3.4.1. K_3EDTA tubes

K_3EDTA tubes were used for blood collection for analysis of Complete Blood Count (CBC) by automated hematology analyzer, MEK-6410, Nihon Kohden, Japan,(figure 3.1). There was no under-filling or overfilling of the blood tubes. Samples were stored in transporting refrigerator containing ice bags and digital thermometer. Upon arrival to the laboratory, CBC was performed at room temperature. The hematological analyzer was calibrated in routine fashion, and calibration was checked using control blood provided by the manufacturer where results were within acceptable range. A CBC was performed on each sample, the data of the parameters Hgb, Hct, RBCs count, MCV, MCH, MCHC, RDW, WBCs count, and PLts count were compiled.

3.4.2. QC and Calibration of the cell counter

Quality control and performance of the cell counter was monitored using hematology control blood (MEK3DN), counted 9 times consecutively. Coefficient of Variation (CV%) was obtained using the built in software for the measured parameters, and found consistent with the specifications by the manufacturer of the machine (Table 3.2) (Kohden, 2006 a). Other accuracy parameters (The Circuit and Background Noise) was checked before calibration and done using hematology control prior to test the study samples. The measured values were within the range of the target values as provided by the manufacturer (Kohden, 2006 a).

Aljabali (2011) evaluated the CBC results according to the types of cell counters that are used in Palestine. We can conclude from his study that Nihon Kohden Celltac alpha attained the highest percentage of excellent performance (Aljabali, 2011). Additionally, it was found by other researchers in Palestine that Nihon Kohden Celltac alpha machine is one of the best cell counters which are available in Palestine (AL-Younis, 2006; Joubeh, 2008).

Figure 3.1: Automatic analyzer with 18 parameters and WBC 3 part differential**.** MEK-6410 Celltac α, Nihon Kohden, Japan.

Table 3.3:*CV% for the measured parameters to control blood (MEK-3DN) before testing the study samples.*

Measured Parameter	CV% according to manufacturer	Measured CV% prior to testing samples
WBC	< 2.0%	1.8%
RBC	<1.5%	1.6%
Hgb	<1.5%	0.6%
Hct	---	1.4%
MCV	<1.0%	0.3%
RDW	---	1.2%
PLts	<4.0%	3.3%

The traditional methods for white and red cell counting have been based on direct hemocytometry of diluted blood in a counting chamber; however, the imprecision and inaccuracy of this technique renders it unsuitable as a reference method (England, 1994).

Nowadays, cell counts on multi-channel automated analyzers are obtained by the number of pulses generated by cells in suspension, when they pass through a small orifice located between two electrodes (aperture impedance/coulter principle) (Figure 3.2) (Lewis et al., 1991; Graham, 2003; https://www.beckmancoulter.com/ 2013).

The used hematology analyzer uses the volumetric impedance method of cell counting. In this method, an electrolytic solution (diluents) containing suspended blood cells is aspirated through the aperture. Two electrodes, an internal electrode and external electrode, are located close to the aperture and a constant current flows between them. When a blood cell passes through the aperture, the resistance between the electrodes momentarily increases and a very small voltage change occurs corresponding to the resistance. The voltage signal is amplified and is sent to the electronic circuit (Kohden, 2006 b).

A threshold circuit eliminates signals caused by electrical noise, dust, debris, and particles which are smaller or larger than blood cells. The signals are sent to A/D converter. The acquired data is stored in memory . The data is corrected by CBU and displayed on the screen. When two or more cells pass through the aperture at the same time (coincidence) (ICSH, 1988; England, 1994), the software contains a coincidence correction table to compensate for this. Blood cell counts, Hgb, and Hct are detected by electrical resistance, surfactant (colorimetric method), and histogram calculation respectively. RDW also is detected by histogram calculation (Kohden, 2006 b).

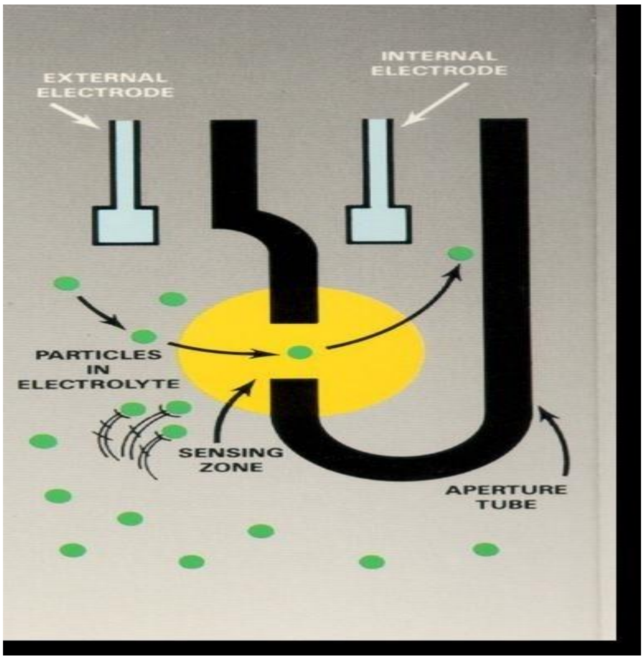


Figure 3.2: Impedance aperture (Google, 2013).

This diagram illustrates the Coulter Principle. The cells in the conductive diluent stream through the aperture within the sensing zone of the electrical field. The cells are counted and sized by the pulse generated (Graham, 2003;https://www.beckmancoulter.com/ 2013).

3.5. Data analysis

At the data processing stage, raw data were reviewed and stored in both forms hard and soft copy. Software version 20 (IBM-SPSS statistics) was used for the statistical analysis. Exclusion criteria applied for every subject has a parameter value located beyond three standard deviations (Natrella, 1963; Osborne, 2004), and cases of chronic disease, heavy smokers, recent blood transfusion, and less than 6 months residency in the place. Accordingly, 23 cases were excluded, and thus 297 students were included in the study. Independent sample t-test was used for calculation of significant differences between two means, along with simple linear correlation. Besides, the statistical significance was set on the level of 0.05 (95%) for all statistical procedures.

Chapter Four: Results

4.1. Study sample and distribution of the questionnaire

In order to evaluate the CBC of those living below sea level in Palestine, along with comparing their CBC results to those who reside above sea level, two cities were chosen to conduct this study: Jericho city, which is located about 300 meters below sea level; and Ramallah city, which is located about 900 meters above sea level.

There are four governmental schools included in the study. The distribution of the schools was based on two schools in Jericho, and two schools in Ramallah. One hundred questionnaires were administered in each school at the beginning of February 2013. The objective of the questionnaire was to collect basic socioeconomic information about the participants such as; smoking, chronic diseases, the residency period in the place, life style, and anthropometric measures.

Table 4.1: Distribution of participating students according to their city location and school grades (class) where N is the number of students.

City location	Participants in the study			
	school Grades/ Classes		Total	
	11th	12th	N	%
Jericho	81	65	146	49.2
Ramallah	89	62	151	50.8
Total	170	127	297	100

However, a total of 320 students accepted to participate in the study and, therefore, filled the questionnaire. According to the criteria of exclusion 297 of them were fit to be included in the study. One hundred and forty six students (49.2%) from Jericho, and one hundred fifty one students (50.8%) from Ramallah. One hundred and seventy students (57.2%) belong to eleventh grade, and one hundred and twenty seven students (42.8%) belong to twelfth grade in both groups. Table 4.1 summarizes the distribution of the study sample between the two cities and school grades, whereas table 4.2 describes age range of the participating students. The age range was 16-19 years.

Table 4.2: Age range of the participants in the study

Age	Frequency	Percent
16	24	8.1%
17	137	46.1%
18	130	43.8%
19	6	2.0%
Total	**297**	**100%**

4.2. Statistical analysis

4.2.1. Analysis of the questionnaire

(Annex II) illustrates the most important information derived from the questionnaire. More than two thirds of the total sample came from cities and about 24% from camps. More than 99% of the students are residents in the places for six months or longer periods. The number of over-weight and obese students is higher in Ramallah (27%) than in Jericho (17%). Consequently, BMI differs significantly between the two groups in favor of Ramallah group (*P=0.006,* table 4.3). Thirty-three percent of participants are smokers and 27.6% of them smoke more than 20 cigarette per day .

4.2.2. Analysis of data (CBC parameters)

For testing the difference between parameters, t-test between two means for independent samples were used. Table 4.3 shows the means of CBC parameters between the two groups.

It was found that there is a statistically significant differences between the means of RBCs counts (*P* = 0.005), Hgb concentration (*P* = 0.001), Hct (*P* = 0.002), Plts counts (*P* = 0.000) and BMI (*P* = 0.006) between the two groups of the study. This difference is due to the altitude difference (Figures 4.1, 4.2, 4.3, 4.4, 4.5). This means that Jericho subjects have lower values for RBC, Hgb, and Hct, while they have higher values for Plts count. This justifies the need for further study to modify the reference range for these parameters for the population living in Jericho.

There are no significant differences between the means of WBC, MCV, MCH, MCHC, and RDW parameters of the two groups ($P > 0.05$) due to altitude variation (about 300 meters below sea level and about 900 meters above sea level).

Table 4.3: Results of t-test for the differences between two means of CBC parameters in the two study groups.

Parameter	PLACE	N	Mean	Std. Deviation	*P*. value
WBC k/µL	Jericho	146	7.1	1.7	0.446
	Ramallah	151	7.0	1.6	
RBC 10^6/µL	Jericho	146	5.2	.36	0.005*
	Ramallah	151	5.3	.37	
HGB g/dL	Jericho	146	14.9	1.0	0.001*
	Ramallah	151	15.3	1.0	
HCT %	Jericho	146	43.6	2.6	0.002*
	Ramallah	151	44.6	2.6	
MCV fL	Jericho	146	84.0	4.2	0.840
	Ramallah	151	84.0	3.9	
MCH pg/cell	Jericho	146	28.6	1.8	0.710
	Ramallah	151	28.7	1.6	
MCHC g/dL	Jericho	146	34.0	.69	0.051
	Ramallah	151	34.2	.58	
PLT k/µL	Jericho	146	290.2	67.9	0.000*
	Ramallah	151	260.6	54.5	
RDW %	Jericho	146	10.6	.44	0.510
	Ramallah	151	10.6	.42	
BMI	Jericho	146	22.2	3.3	0.006*
	Ramallah	151	23.3	3.7	

**P*, value shows significant difference

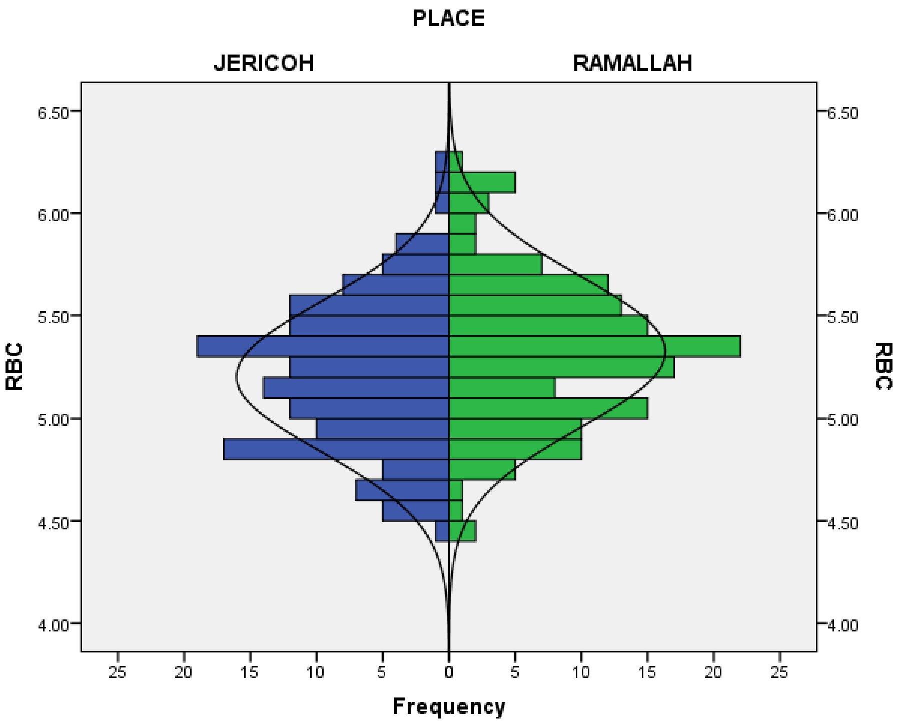


Figure 4.1*:* Distribution of RBCs counts of the two groups, below sea level (Jericho group) and above sea level(Ramallah group), *P* = 0.005.

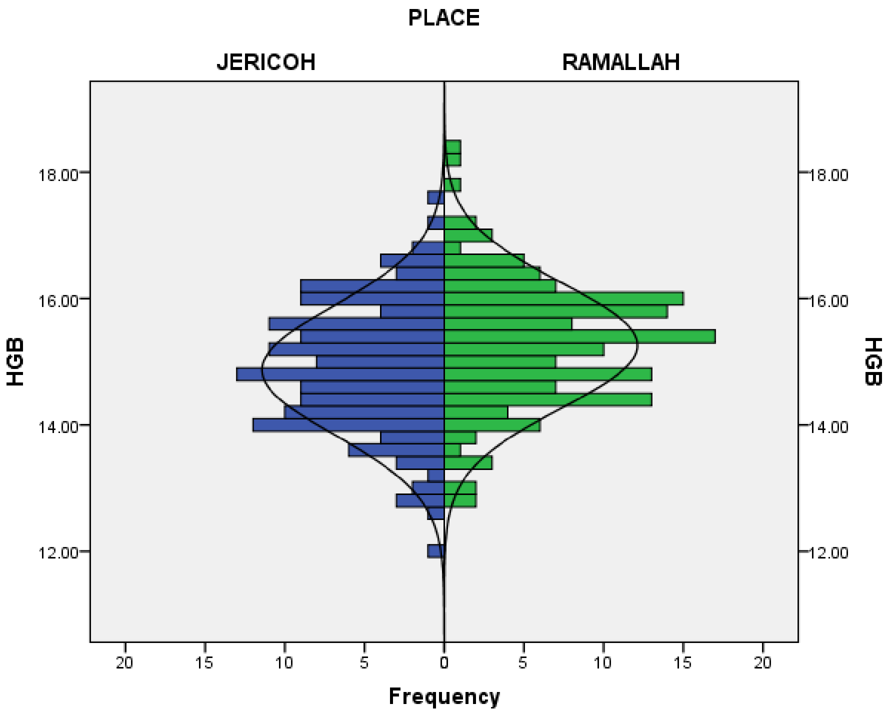


Figure 4.2: Distribution of Hgb concentration of the two groups, below sea level (Jericho group) and above sea level (Ramallah group), $P = 0.001$.

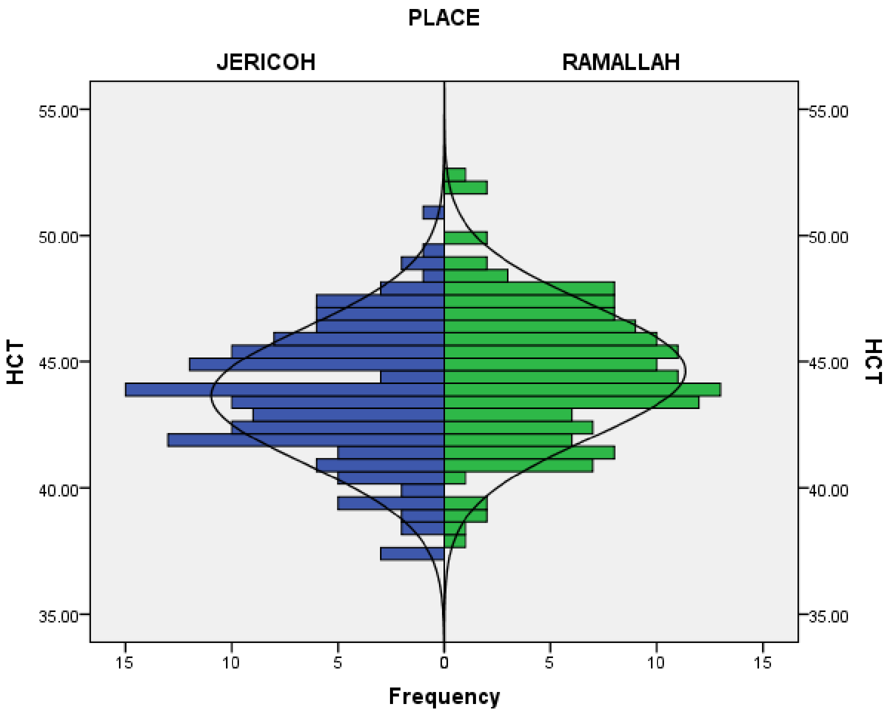


Figure 4.3*:* Distribution of Hct of the two groups, below sea level (Jericho group) and above sea level (Ramallah group), *P* = 0.002.

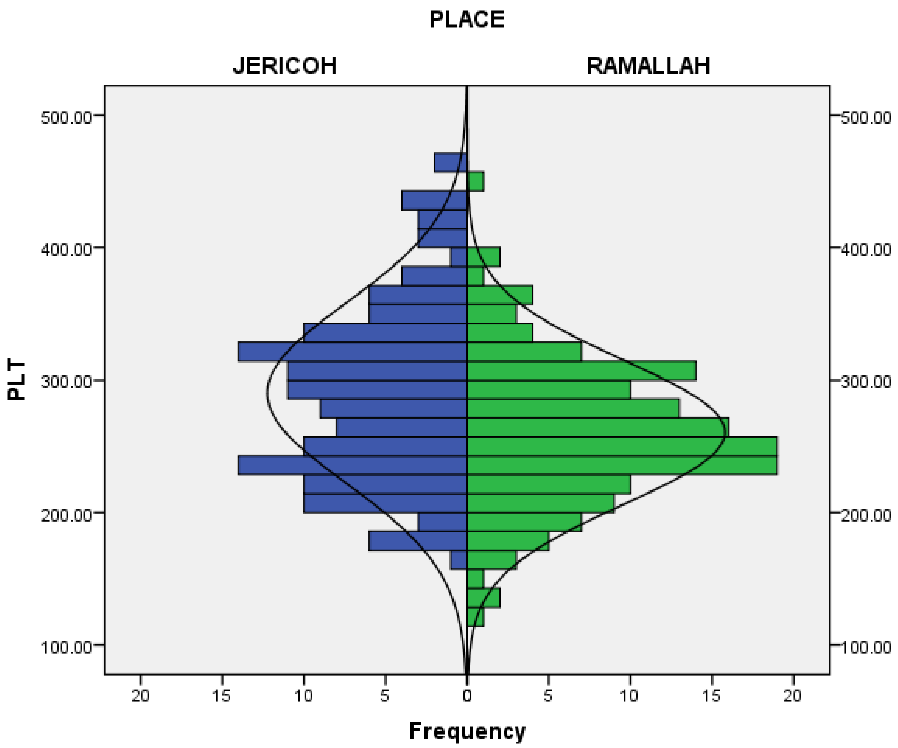


Figure 4.4: Distribution of PLT counts of the two groups, below sea level (Jericho group) and above sea level (Ramallah group), *P* = 0.000.

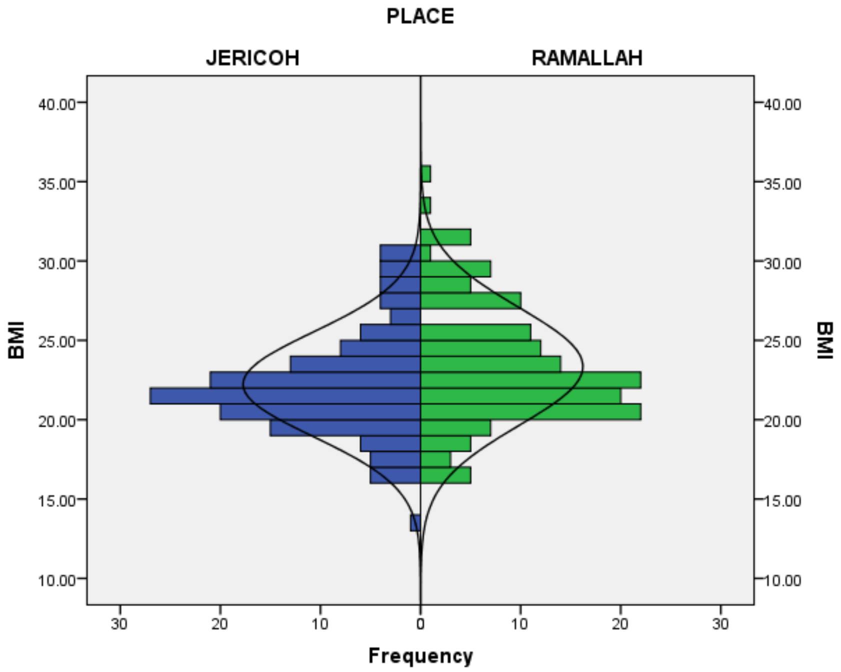


Figure 4.5*:* Distribution of BMI of the two groups, below sea level (Jericho group) and above sea level (Ramallah group), *P* = 0.006.

4.3. Results of t-test for reference ranges: a comparison of this study and international ones.

Reference ranges of the main CBC parameters for our study were compared with the international reference ranges that were derived from valued references using t-test (Harmening, 2006; Hoffbrand et al., 2011; Mayoclinic, 2013).

Table 4.4A shows a comparison of reference ranges of main CBC parameters for our study in Ramallah group with international ones for adult males (n =151, age = 16-19 years).

There are statistical significant differences between reference range for WBC counts in our study and those derived from Hoffbrand study and Harmening study (*P* < 0.01, < 0.001) respectively. Computed t-test values on RBC counts with all the three: Hoffbrand , Harmening and Mayoclinic studies were (*P* < 0.001). This means that there are significant differences between our study and international studies in RBC reference range.

For Hgb parameter *P* value was less than 0.01 when comparing our study with international ones. This means that Hgb reference ranges in our study is statistically different from international reference range. There was a significant difference between MCV reference range when compared with Hoffbrand , and Harmening, taking into consideration that *P* value was less than 0.001 in both studies. There is a significant difference in PLT counts between our study and Hoffbrand , Harmening and Mayoclinic studies with ($P < 0.05, < 0.05, < 0.001$) respectively.

Table 4.4A: Comparison of some CBC reference ranges for our study in Ramallah (n =151, age =16-19 years) with international ones for adult males using t-test.

Parameter	**Hoffbrand Book**	**Harmening Book**	**Mayoclinic Study**	**Our study**
WBC k/µL	4.0-11.0	4.8-10.8	3.5-10.5	3.7-10.3
***P* value**	< 0.01	< 0.001	> 0.05	
RBC10^6/µL	4.5-6.5	4.5-6.1	4.32-5.72	4.6-6.1
***P* value**	< 0.001	< 0.001	< 0.001	
Hb gm/dL	13.5-17.5	14.0-18.0	13.5-17.5	13.3-17.2
***P* value**	< 0.01	< 0.01	< 0.01	
MCV fL	80-95	80-100	NA	76-92
***P* value**	< 0.001	< 0.001		
Platelet k/µL	150-400	150-350	150-450	152-370
***P* value**	< 0.05	< 0.05	< 0.001	

NA= Not available, K = Kilo, uL= microliter, gm = Gram, dL=Deciliter, fL= Femtoliter.

Table 4.4B shows a comparison of reference ranges of main CBC parameters for our study in Jericho group (n =146, age =16-19 years) with international ones for adult males.

Table 4.4B: Comparison of some CBC reference ranges for our study in Jericho (n = 146, age = 16-19 years) with international ones for adult males using t-test.

Parameter	**Hoffbrand Book**	**Harmening Book**	**Mayoclinic Study**	**Our study**
WBC k/µL	4.0-11.0	4.8-10.8	3.5-10.5	3.7-10.6
***P* value**	< 0.05	< 0.001	> 0.05	
RBC10^6/µL	4.5-6.5	4.5-6.1	4.32-5.72	4.5-5.9
***P* value**	< 0.001	< 0.05	< 0.01	
Hb gm/dL	13.5-17.5	14.0-18.0	13.5-17.5	12.8-16.9
***P* value**	< 0.001	< 0.001	< 0.001	
MCV fL	80-95	80-100	NA	76-92
***P* value**	< 0.001	< 0.001		
Platelet k/uL	150-400	150-350	150-450	154-422
***P* value**	< 0.01	< 0.001	< 0.05	

NA= Not available, k = Kilo, uL= microliter, gm = Gram, dL=Deciliter, fL= Femtoliter.

There are significant differences between reference range for WBC counts in our study and those adopted from Hoffbrand (2011) study and Harmening (2006) study ($P < 0.05 < 0.001$) respectively. Computed t-test values on RBC counts with all the three: Hoffbrand, Harmening and Mayoclinic studies were ($P < 0.001$, $< 0.05 < 0.01$) respectively. This means that there are significant differences between our study and international studies in RBC reference range.

P value for Hgb parameter was less than 0.001 when compared between our study and international ones. This means that Hgb reference ranges in our study is statistically different from international reference range. There was significant difference between MCV reference range when compared with Hoffbrand (2011) and Harmening (2006) were *P* value was less than (0.001) with both studies. There is a significant difference in Plts counts between our study and Hoffbrand, Harmening and Mayoclinic studies with (

$P < 0.01$, < 0.001, < 0.05) respectively. These findings justify the need to establish our own CBC reference ranges.

Chapter five: Discussion

5.1. Introduction

CBC is a highly informative multi-parameter test which helps in diagnosing many hematological and non-hematological conditions. Clinicians usually use it as a primary investigation to evaluate the human body state. CBC is usually used as a screening test for asymptomatic individuals, and with differential leukocyte count (DIFF) is an important part of clinical laboratory analyses Where it provides crucial data for clinicians (George-Gay and Parker, 2003; Cornet et al., 2012).

Total pressure of all gases in the air "barometric pressure" decrease while the altitude increases. By reducing barometric pressure, there is a proportional reduction in the oxygen partial pressure, which is always consisted of less than 21% of total barometric pressure. When the function of erythropoietin is normal, hypoxia causes increase in erythropoietin secretion from the granular juxtaglomerular cells in kidneys, which stimulates erythrocytopoiesis (Harry, 1964). When a man is moved from the low oxygen atmosphere, there is an increase in the value of oxygen that is transported to tissues above normal value and, thus, erythropoietin secretion stops immediately.

For the first time in Palestine, this study was designed to evaluate the CBC of those people who live below sea level, and comparing them with those who live above sea level. The importance of this study lies in providing more effective answers to the clinical request and helping clinicians in more accurate understanding and interpretation for the CBC results. Additionally, provide affluent for the literature with such unavailable data. It is also aimed to some extent at assessing the need for a new own

CBC reference range for those living below sea level. Because the effect of living below sea level on CBC parameters is not sufficient and not well studied before, this study aimed at bridging this gap, where we depicted the CBC parameters for those living about 300 meter below the sea level. Additionally, local reference ranges of CBC parameters were compared with international ones to evaluate the applicability of the used reference ranges on the young adult males.

Four secondary male schools were chosen for the study, two located about 300 meters below sea level, and two located about 900 meters above sea level. 320 participants were randomly chosen with age ranged from 16 to 19 years old. The nine basic components of CBC which tracked in this study are: WBCs, RBCs, Plts, Hgb, Hct, RDW, and red blood cell indices MCV, MCH and MCHC.

5.2.Results of our study

At above sea level, our study results revealed that there is a significant increase in Hgb concentration, RBC counts and Hct levels compared to those living below sea level. These results are consistent with many previous studies: (Harry, 1964; Levine and Stray-Gundersen, 1997; Makeshova et al., 2004; Savourey et al., 2004; Spicuzza et al., 2004; Christoulas et al., 2011; Al-Sweedan and Alhaj, 2012). The reduction in oxygen saturation at high altitude stimulates excessive erythrocytosis as a result of the increase in erythropoietin stimulation. This may be an important factor promoting erythropoiesis, but its relevance needs to be further explored. It is suggested that in population living at high altitudes, long-term adaptation to hypoxia gives rise to an original mechanism of erythropoiesis regulation when all coming iron participates in hemoglobin synthesis without iron deposition. Under hypoxic hypoxia, regulation of erythropoiesis is directed to prevention of tissue hypoxia.

The increment in erythropoiesis rate and Hgb synthesis at high altitude is due to elevation in the erythropoietin secretion that is caused by hypoxia state. Restoration of the appropriate oxygenation status in the arteries is the goal of these complicated mechanisms through the increase in oxygen-carrying capacity. This allows for lower cardiac output and therefore more peripheral diffusion time and oxygen extraction (Levine and Stray-Gunderse, 1997). There are many studies describing the mechanisms of acclimatization to high altitude and its effect on Complete Blood Count CBC parameters and on athlete's performance. Mostly, these studies stating that there is increase in Hgb concentration, erythropoiesis and erythropoietin secretion at high altitude with no significant differences between the two genders (Al-Hashem, 2006; Windsor and Rodway, 2007; Clark et al., 2009; Al-Sweedan and Alhaj, 2012; Gough et al., 2012), while there is infrequency in the data available about the effect of living below sea level on CBC test results (Al-Sweedan and Alhaj, 2012).

The increase amount of Hgb in acclimated person make possible that one liter of blood at high altitude can hold out the same level of oxygen as at the sea level. There are data that in the process of acclimatization the level of myoglobin in the muscles and the number of capillaries increase which also help in the oxygen utilization. Although many researches were done to define optimal conditions of the acclimatization, this matter has not been completely solved yet.

Al-Sweedan and Alhaj (2012) stated that males who lived above sea level had a higher Hgb concentration, MCV, and WBC count than males who lived below sea level. On the other hand, males who lived below sea level had higher platelet count and RDW than males who lived above sea level. Their results for Hgb, Hct, RBCs and platelets are consistent with our findings. Higher means of WBC counts and MCV at above sea level may reflect selection of unhealthy individuals, as the range of WBC among their subjects was 3.2-26.3 k/uL. Additionally, Hgb range for the same group was 10.3-17.9 g/dL which also does not reflect healthy status in adults. They did not explain also on what statistical basis they excluded the outliers, as we did in our study. Al-Sweedan and Alhaj (2012) subjects aged between 18-35 years old, who had reported to the blood bank at King Abdullah University Hospital (KAUH)/ Irbid and Ministry of Health, Jordan, in eighteen month period, which may reflect high variation in the study sample. Our study sample groups were well uniformed at many levels including age group, residency place and period, genetic background, advance preparation of the subjects, and time of sampling and phlebotomy procedure. This gives advantage to our study in its rigor and reliability to be considered as an original research report evaluating the CBC parameters for those who live below sea level in Palestine.

Our findings for Hgb and Hct also agree with Albahsh (2011) findings although they measured Hgb and Hct manually.

There is a conflict between the limited studies in the literature about the effect of altitude on PLT counts. In our study, Plts counts in below sea level were significantly higher than in above sea level students, which can be explained by various factors including iron stores of the subjects. It is easier to interpret the lower Plts at high altitude than to explain the higher Plts at low altitude. At high altitude there is a decrease in plasma volume (Heinicke et al., 2003) and increase in erythrocytes (Spicuzza et al., 2004; Li et al., 2011). This may contribute to higher blood viscosity and slow blood flow. These acclimatization changes may lead to tendency to thrombosis, and it is proven that polycythemia, both primary and secondary, is related to thrombosis (Fujimaki et al., 1986). Lower Plts counts at high altitude may be considered as natural mechanism defense against this risk to thrombosis with unknown etiology(Al-Sweedan and Alhaj, 2012). Our results which showed increase in Plts at below sea level are in agreement with the results of Al-Sweedan and Alhaj (2012), the only study was formerly discussed the CBC at below sea level.

There are significant differences between the two groups in BMI ($P = 0.006$). There is increase with body mass index in Hgb concentration in both men and women, but this change is not enough to cause significant differences (Nordin et al., 2004).

These findings justify the need to modify the reference range for Hgb, Hct, RBC, and platelets for those living below sea level. This modification gives better interpretation of results for the clinicians.

5.2.1. Reference ranges of our study in comparison with the international studies

There are many ongoing studies for defining reference interval throughout the world in general, and several projects throughout Europe in particular. It is now a proven fact that there is considerable variation in hematology reference ranges depending on demographic and pre-analytical variables. There are evidences which state that values provided by manufacturers are not appropriately applicable for all populations. Moreover, reference ranges provided by deferent laboratory manuals and books also do not solve this problem. We are evaluating in this study CBC reference ranges for 16-19 years old Palestinian males. Results from this study showed that almost all CBC parameters in both Ramallah and Jericho differ significantly from those in the international studies. This justifies the need to establish our own reference ranges for this age group and for adult male population in general.

Before this study, there was no published data available locally on the normal reference ranges of CBC parameters in healthy young adult males. Reference ranges are necessary in hematology to compare observed values and to provide meaningful information. It is of high importance to establish our own reference ranges before interpreting any results to clinical setting. Lack of clarity between normality and abnormality in laboratory results continues to cause difficulty in interpretation of patient results (Wakeman et al., 2007). Perfect adherence to the ICSH recommendations is almost impossible. Nevertheless, it is important that all laboratories should construct their own local reference ranges for their specific analytical systems before cost effective clinical decisions can be made (Trowbridge et al., 1989). Variances in the ethnic composition of the local society should also be considered when establishing a reference range (Wakeman et al., 2007). The diversity of the population in this study was very low which reflects the local population.

Reference ranges for near normally distributed parameters were calculated using ± 2 SDs (Wakema et al., 2007). Results of our study demonstrated that there were significant differences for majority of CBC parameters from other international published data (Tables 4.5A and 4.5B) which confirms that a local establishment of reference ranges are essential for any population (Milman et al., 2001).

The ranges of Hgb and RBC showed significantly lower levels than the international ranges in general. This may require re-identification of the normality limits to differentiate anemic from normal individuals in this age group.

The literature and the manufacturer's reference ranges should only be used as a guide, and the reference normal results should match with the local population (Roshan et al., 2009). Based on our results, we have derived new values that can discriminate microcytic from macrocytic erythrocytes in this age group. Reference range of MCV is different in comparison with the one provided by the manufacturers or laboratory manuals. Formerly, we were using the MCV value of 80 fL to differentiate between normocytic and microcytic cells, however, our results assess that it has to be changed to 76 fL for this age group.

Range of WBC counts in both groups showed significant decrement when compared with the international ranges. However, leucocyte counts are at their lowest in the morning (Wakeman et al., 2007), it is when the samples of our study were collected, in addition to other factors including the advance preparation of the participants who were asked to avoid stress such as exercise, selecting healthy students, and exclusion of outliers.

Reference limits determined for Plts counts in Ramallah are significantly lower than international ranges, while they were significantly higher than international ranges in Jericho. Factors that contribute to such outcome are not well explained in the literature.

5.3.Conclusions and recommendations

We found significant differences in CBC parameters among young adult males living below and above sea level. Our study results revealed that At above sea level there is a significant increase in Hgb concentration ($P = 0.001$), RBC counts ($P = 0.005$) and Hct levels ($P = 0.002$) compared to those living below sea level. A large convenient random sample in a well-designed study is considered the first one in Palestine, and almost the second at the level of the world.

Depending on our results, we conclude that the majority of the reference ranges of CBC parameters among Palestinian young adult males are different compared with international studies and the ones provided in the reference books. There are significant differences between reference range for WBC counts, RBC counts, Hgb concentration, MCV, and Plts counts between our study and international ones. New and locally established reference ranges should be referred to before interpretation of any laboratory tests. We believe that separate sets of reference ranges for local and universal basis should be used in health and disease for all age groups.

On the light of the previous results and discussion, the following recommendations can be raised:

1- Conducting further wider and supported studies for establishing the own CBC reference ranges for Palestinian people, with priority to those who live below sea level.
2- Conducting further research to determine period of time that is required for making such effect, and to specify the smallest changes of altitude that are needed for appearance of this effect to minimize unnecessary suffering from exposure to additional hypoxia.
3- Our findings underlined the importance of considering geographic and environmental factors when using hematological reference ranges for healthy or septic partitioned age groups.
4- Re-definition of the differentiation limits between the normality and abnormality of CBC parameters such as anemic versus healthy, and thalassemia trait suspect from none.
5- Reference ranges issued with laboratory results should be titled with " local reference range" or " universal reference range" so that accurate assessment can be made.

References

Albahsh, F. O. (2001). The Effect of Altitude on Blood Biochemistry of Soccer Players in West Bank. Master thesis, An-Najah National University, Nablus – Palestine.

Al-Hashem, F. H. (2006). Pattern of haemoglobin among high and low altitude children of southwestern Saudi Arabia. Family Community Med, 13(1): 35-40.

Al-Sweedan, S. A., & Alhaj, M. (2012). The effect of low altitude on blood count parameters. Hematol Oncol Stem Cell Ther,5, 158-161.

AL-Younis K., Alzeer, A. N. N. J. (2006). Precision & Accuracy In Cell Counters. Medical Laboratory Sciences. Beirzit University, Beirzeit – Palestine.

Aljabali, O. (2011). Evaluation of quality control in the hematology laboratories in the West Bank-Palestine: A consensus study. AL- Quds - Palestine: Master thesis, AL-Quds University.

Alper, A. T., Sevimli, S. H., Hasdemir, Z. Nurkalem, T. S. Guvenc, A. A., Cakmak, N. G., … Gurkan, K. (2009). Effects of high altitude and sea level on mean platelet volume and platelet count in patients with acute coronary syndrome. J Thromb Thrombolysis, 27, 130-134.

Altschuler, E. L. & Kast, R.E. (2005). Using histamine (H1) antagonists, in particular atypical antipsychotics, to treat anemia of chronic disease via interleukin-6 suppression. Med Hypotheses, 65, 65-67.

Bain, B., Seed, M., & Godsland, I. (1984). Normal values for peripheral blood white cell counts in women of four different ethnic origins. J Clin Pathol, 37, 188-193.

Barger, A. M. (2003). The complete blood cell count: a powerful diagnostic tool. Vet Clin North Am Small Anim Pract, 33, 1207-1222.

Bender, P. R., Groves, B.M., McCullough, R.E., McCullough, R.G., Trad, L., Young, A.J. & Reeves, J.T. (1989). Decreased exercise muscle lactate release after high altitude acclimatization. J Appl Physiol, 67, 1456-1462.

Bergman, B. C., G. E. Butterfield, E. E. Wolfel, G. D. Lopaschuk, G. A. Casazza, M. A. Horning and G. A. Brooks (1999). "Muscle net glucose uptake and glucose kinetics after endurance training in men." Am J Physiol, **277**(1 Pt 1): E81-92.

Besarab, A. & Soman, S. (2005). Anemia management in chronic heart failure: lessons learnt from chronic kidney disease. Kidney Blood Press Res, 28, 363-371.

Beutler, E., A., Hoffbrand, V.& Cook, J.D. (2003). Iron deficiency and overload. Hematology Am Soc Hematol Educ Program, 40-61.

Braekkan, S. K., Mathiesen, E.B., Njolstad, I., Wilsgaard, T., &Hansen, J.B. (2010). Hematocrit and risk of venous thromboembolism in a general population. The Tromso study. Haematologica, 95, 270-275.

Braekkan, S. K., Mathiesen, E. B., Njolstad, I., Wilsgaard, T., Stormer J., &Hansen J. B. (2010). Mean platelet volume is a risk factor for venous thromboembolism: the Tromso Study, Tromso, Norway. J Thromb Haemost, 8, 157-162.

Buttarello, M. (2004). Quality specification in haematology: the automated blood cell count. Clin Chim Acta, 346, 45-54.

Carl A. Burtis, E. R. A. (2001). Fandamentals of clinical chemistry (ed.).St Louis, Mo: Saunders Elsevier.

Carneiro, I. A., Drakeley, C. J., Owusu-Agyei, S., Mmbando, B., & Chandramohan, D. (2007). Haemoglobin and haematocrit: is the threefold conversion valid for assessing anaemia in malaria-endemic settings? Malar J, 6, 67.

Carr, B. I. & Guerra, V. (2013). Thrombocytosis and Hepatocellular Carcinoma. Dig Dis Sci.

Chatterji, J. C., Ohri, V. C., Das, B. K., Chadha, K. S., Akhtar, M., Bhatacharji, P., Behl A. (1982). Platelet count, platelet aggregation and fibrinogen levels following acute induction to high altitude (3200 and 3771 metres).Thromb Res, 26, 177-182.

Christensen, C. C., Ryg, M. S., Refvem O. K.,& Skjonsberg O. H. (2002). Effect of hypobaric hypoxia on blood gases in patients with restrictive lung disease. Eur Respir J, 20, 300-305.

Christoulas, K., Karamouzis M.& Mandroukas K. (2011). Living high - training low" vs. "living high - training high: erythropoietic responses and performance of adolescent cross-country skiers. J Sports Med Phys Fitness, 51,74-81.

Clark, S. A., Quod, M.J., Clark, M. A., Martin, D. T., Saunders, P. U. & Gore, C. J. (2009). Time course of haemoglobin mass during 21 days live high: train low simulated altitude. Eur J Appl Physiol, 106(3): 399 406.

Connett, R. J., C. R. Honig, T. E. Gayeski and G. A. Brooks (1990). "Defining hypoxia: a systems view of VO2, glycolysis, energetics, and intracellular PO2." J Appl Physiol ,**68** (3): 833-842.

Cornet, E., C., Behier, & Troussard, X. (2012). Guidance for storing blood samples in laboratories performing complete blood count with differential. Int J Lab Hematol.

Cymerman, A., Reeves, J. T., Sutton, J. R., Rock, P. B., Groves, B. M., Malconian, Houston, C. S. (1989). Operation Everest II: maximal oxygen uptake at extreme altitude. J Appl Physiol, 66, 2446-2453.

Da Costa, L., Galimand, J., Fenneteau, O.,& Mohandas, N. (2013). Hereditary spherocytosis, elliptocytosis, and other red cell membrane disorders. Blood Rev.

Demopoulos, H. B., Highman, B., Altland, P. D., Gerving M. A.,& Kaley G. (1965). Effect of High Altitude on Granular Juxtaglomerular Cells and Their Possible Role in Erythropoietin Production. Am J Pathol, 46, 497-509.

Dixon, L. R. (1997). The complete blood count: physiologic basis and clinical usage. J Perinat Neonatal Nurs, 11, 1-18.

Domenech, E., Manosa, M., Masnou, H., Navarro, M., Garcia-Planella, E., Bernal I., & Gassull M. A. (2005). Infliximab for the treatment of chronic anemia in Crohn's disease. Am J Gastroenterol, 100, 496.

Dosek, A., Ohno, H., Acs, Z., Taylor A. W.,& Radak Z. (2007). High altitude and oxidative stress. Respir Physiol Neurobiol, 158, 128-131.

Emerk, M. A. a. K. (2008). Accurate reference intervals are required for accurate diagnosis and monitoring of patients. eJIFCC, 19.

England, J. M. (1994). Reference method for the enumeration of erythrocytes and leucocytes. International Council for Standardization in Haematology; prepared by the Expert Panel on Cytometry. Clin Lab Haematol, 16, 131-138.

Erne, P., Wardle, J., Sanders, K., Lewis, S. M.,& Maseri, A. (1988). Mean platelet volume and size distribution and their sensitivity to agonists in patients with coronary artery disease and congestive heart failure. Thromb Haemost, 59, 259-263.

Faura, J., Ramos, J., Reynafarje, C., English, E., Finne, P., & Finch, C. A. (1969). Effect of altitude on erythropoiesis. Blood, 33, 668-676.

Fischbach, F. (2004). A manual of Laboratory and Diagnostic Tests. China: Lippincott Williams and Wilkins.

Fujimaki, T., Matsutani, M., Asai, A., Kohno, T. & Koike, M. (1986). Cerebral venous thrombosis due to high-altitude polycythemia. Case report. Neurosurg, 64(1): 148-150.

Gary, L.& Horowitz, M. (2008). Reference intervals: practical aspects. eJIFCC, 19.

George-Gay, B. & Parker K. (2003). Understanding the complete blood count with differential. J Perianesth Nurs, 18, 96-114.

Gippenreiter, E. & West, J. B. (1996). High altitude medicine and physiology in the former Soviet Union. Aviat Space Environ Med, 67, 576-584.

Godon, A., Genevieve, F., Marteau-Tessier, A.,& Zandecki, M. (2012). Automated hematology analysers and spurious counts Part 3. Haemoglobin, red blood cells, cell count and indices, reticulocytes. Ann Biol Clin (Paris), 70, 155-168.

Gonzales, G. F. (2011). Hemoglobin and testosterone: importance on high altitude acclimatization and adaptation. Rev Peru Med Exp Salud Publica, 28, 92-100.

Goodford, P. J., Norrington, F. E., Paterson R. A.,& Wootton R. (1977). The effect of 2,3-diphosphoglycerate on the oxygen dissociation curve of human haemoglobin. J Physiol, 273, 631-645.

Goodnough, L. T., Skikne B.,& Brugnara, C. (2000). Erythropoietin, iron, and erythropoiesis. Blood, 96, 823-833.

Google (2013). Coulter principle. Retrieved from https//: www.google.ps/search?q=coulter%20principle.

Gough, C. E., Saunders, P. U., Fowlie, J., Savage, B., Pyne, D. B., Anson, J. M,…Gore C. J. (2012). Influence of altitude training modality on performance and total haemoglobin mass in elite swimmers. Eur J Appl Physiol, 112(9): 3275-3285.

Graham, M. D. (2003). The Coulter Principle: Foundation of an Industry. Association for Laboratory Automation, 8,72-81.

Gray, G. W., Bryan, A. C., Freedman, M. H., Houston, C. S., Lewis, W. F., McFadden, D. M.,& G. Newell (1975). Effect of altitude exposure on platelets. J Appl Physiol, 39, 648-652.

Green, H. J., Sutton, J., Young, , P., Cymerman, A. &Houston, C. S. (1989). Operation Everest II: muscle energetics during maximal exhaustive exercise. J Appl Physiol, 66, 142-150.

Grocott, M., Montgomery, H.& Vercueil, A. (2007). High-altitude physiology and pathophysiology: implications and relevance for intensive care medicine. Crit Care, 11, 203.

Gunga, H. C., Fries, D., Humpeler, E., Kirsch, K., Boldt, L. E., Koralewski, Schobersberger, W. (2003). Austrian Moderate Altitude Study (AMAS 2000) - fluid shifts, erythropoiesis, and angiogenesis in patients with metabolic syndrome at moderate altitude (congruent with 1700 m). Eur J Appl Physiol, 88,497-505.

Gunga, H. C. & Kirsch, K. A. (1995). Nathan Zuntz (1847-1920)--a German pioneer in high altitude physiology and aviation medicine, Part I: Biography. Aviat Space Environ Med, 66, 168-171.

Hackett, D. P. (2013). Retrieved fromhttp://www.altitudemedicine.org/.

Hall, F. W. & Lundgrin, D. B. (1987). Screening for alpha-thalassemia in neonates. Routine erythrocyte measurements. Am J Clin Pathol, 87, 389-391.

Harmening, D. M. (2006). Clinical Hematology and Fundamentals of Hematology. USA: F. A. Davis Compoany Philadelphia.

Harry, B., Demopoulos, B. H., Paul, D., Altland, Martha A., Gerving, & Gabor, K. (1964). Effects of high altitude on granular juxtaglomerular cells and their possible role in erythropoietin production.

Harvey, L., BERK, A., Kaiser, C. A., Krieger, M., Scot, M. P., Bretscher, A., Matsudaira, P. (2008). Molecular Cell Biology. New York: W. H. Freeman and Company.

Heinicke, K., Prommer, N., Cajigal, J., Viola, T., Behn, C., &Schmidt, W. (2003). Long-term exposure to intermittent hypoxia results in increased hemoglobin mass, reduced plasma volume, and elevated erythropoietin plasma levels in man. Eur J Appl Physiol, 88, 535-543.

Hoffbrand, A.V., Catovsky, D., Tuddenham, E. G. D., & Green, A. R. (2011). Postgraduate Haematology (6th ed.). UK: WIley-Blackwell.

https://www.beckmancoulter.com/. (2013). "Coulter Counter Analyzers." from https://www.beckmancoulter.com/.

ICSH. (1988). Recommendations for neonatal screening for haemoglobinopathies. International Committee for Standardization in Haematology. ICSH Expert Panel on Abnormal Haemoglobins. Clin Lab Haematol, 10, 335-345.

International Committee for Standardization in Haematology (ICSH). (1982). Standardization of blood specimen collection procedure for reference values. Clin Lab Haematol, 4, 83-86.

Irwin, J. J. & Kirchner, J. T. (2001). Anemia in children. Am Fam Physician, 64, 1379-1386.

James, N. & Parker, M. D. (2007). Beta Thalassemia A Bibliography And Dictionary For Physicians, Patients, And Genome Researchers. P. D. Philip M. Parker. USA, San Diego, Health Care: Philip Parker, Ph.D.

Jefferson, J. A., J. Simoni, E. Escudero, M. E. Hurtado, E. R. Swenson, D. E. Wesson, G. F. Schreiner, R. B. Schoene, R. J. Johnson and A. Hurtado (2004). "Increased oxidative stress following acute and chronic high altitude exposure." High Alt Med Biol ,**5**(1): 61-69.

Jensen, A. V., &Alt, H. L. (1945). Effect of intermittent exposure to simulated high altitude in erythropoiesis in the guinea pig. Proc Soc Exp Biol Med, 60, 384-386.

Joanny, P., Steinberg, J., Robach, P., Richalet, J. P., Gortan, C., Gardette, B. & Jammes, Y. (2001). Operation Everest III (Comex'97): the effect of simulated sever hypobaric hypoxia on lipid peroxidation and antioxidant defence systems in human blood at rest and after maximal exercise. Resuscitation, 49, 307-314.

Joubeh, N. (2008). Quality Assurance on Cell Counters in West Bank. Master thesis, Birzeit University, Birzeit - Palestine.

Julian, R. J., Mirsalimi, S. M.,& Squires, E. J. (1993). Effect of hypobaric hypoxia and diet on blood parameters and pulmonary hypertension-induced right ventricular hypertrophy in turkey poults and ducklings. Avian Pathol, 22, 683-692.

Kayiran, S. M., Ozbek, N., Turan, M.,& Gurakan, B. (2003). Significant differences between capillary and venous complete blood counts in the neonatal period. Clin Lab Haematol, 25, 9-16.

Kent, M. (2013). The Oxford Dictionary of Sports Science & Medicine. Oxford: Oxford University Press.

Kohden, N. (2006 a). Operator's Manual, MEK-6410/MEK-6420 Automated Hematology Analyzer.

Kohden, N. (2006 b). Service Manual, MEK-6400/MEK-6410/MEK-6420 Automated Hematology Analyzer. N. Kohden.

http://labtestsonline.org/understanding/analytes/cbc/tab/test

Lehmann, T., Mairbaurl, H., Pleisch, B., Maggiorini, M., Bartsch, P., &Reinhart, W. H. (2006). Platelet count and function at high altitude and in high-altitude pulmonary edema. J Appl Physiol, 100, 690-694.

Lenfant, C., Torrance, J., English, E., Finch, C. A., C. Reynafarje, C. , Ramos, J.,& Faura, J. (1968). Effect of altitude on oxygen binding by hemoglobin and on organic phosphate levels. J Clin Invest, 47, 2652-2656.

Letter, M. C. H. (2001). The ABCs of CBC. A common blood test. Mayo Clin Health Lett, 19, 4-5.

Levine, B. D. & Stray-Gundersen, J. (1997). Living high-training low: effect of moderate-altitude acclimatization with low-altitude training on performance. J Appl Physiol, 83, 102-112.

Lewis, D. a., Ed. (2012).Practical Haematology (ed.). USA: Churchill Livingstone Elsevier.

Lewis, S. M. (1988). Getting the right answers from blood. World Health Forum, 9, 575-581.

Lewis, S. M., Bain, B. J., Bates, I., Dacie, J. V., & Dacie, J. V. (2006). Dacie and Lewis practical haematology. Philadelphia: Churchill Livingstone/Elsevier.

Lewis, S. M., England, J. M.,& Rowan, R. M. (1991). Current concerns in haematology. 3: Blood count calibration. J Clin Pathol, 44, 881-884.

Li, P., Huang, J., Tian, H. J., Huang, Q. Y., Jiang, C. H. & Gao, Y. Q. (2011). Regulation of bone marrow hematopoietic stem cell is involved in high-altitude erythrocytosis. Exp Hematol, 39 (1): 37-46.

Luzzatto, G., de Franchis, G., Fabris, F., Gerunda, G. E., & Girolami, A. (1988). Increased proportion of giant platelets and platelet distribution width are better indicators of altered platelet homeostasis than mean platelet volume in liver cirrhosis. Folia Haematol Int Mag Klin Morphol Blutforsch, 115, 719-726.

Makeshova, A. B., Levina, A. A., Mamukova Iu, I.,& Raimzhanov, A. R. (2004). Characteristics of erythropoiesis regulation in population living at high altitude. Ter Arkh, 76, 95-97.

Martinez, P. M., Garcia de Vinuesa, S., Ortega Diaz, M., Goicoechea, M., Gomez Campdera, F., & Luno, J. (2005). Evaluation of efficacy of darbepoetin alfa administered once monthly as treatment of anemia in predialysis patients with chronic kidney disease. Nefrologia, 25, 663-667.

Matsuno, K.& Ishizuka, S. (1998). New technology of automated blood cell differential counting. Rinsho Byori, 46, 361-366.

Mayoclinic, (2013). Mayo Foundation for Medical Education and Research. Retrieved from: http://www.mayoclinic.com/health/complete-blood-count.

McPhee, S.J., Hammer, G. D. (2010). Pathophysiology of Disease, An Introduction to Clinical Medicine(ed.). New York: Mc Graw Hill Lang.

Messinezy, M. & Pearson, T. C. (1997). ABC of clinical haematology. Polycythaemia, primary (essential) thrombocythaemia and myelofibrosis. BMJ, 314, 587-590.

Miller, L. E., McGinnis, G. R., Kliszczewicz, B., Slivka, D., Hailes, W., Cuddy, J., Dumke, C., Ruby, B.,& Quindry, J. C. (2013). Blood oxidative-stress markers during a high-altitude trek. Int J Sport Nutr Exerc Metab, 23, 65-72.

Milman, N., K. E. Byg, G. Mulvad, H. S. Pedersen and P. Bjerregaard (2001). "Haemoglobin concentrations appear to be lower in indigenous Greenlanders than in Danes: assessment of haemoglobin in 234 Greenlanders and in 2804 Danes." Eur J Haematol, **67**(1): 23-29.

Muncie, H. L., & Campbell, J. (2009). Alpha and beta thalassemia. Am Fam Physician, 80, 339-344.

Natrella, M. G. (1963). Experimental Statistics, National Bureau of Standards, Handbook 91."

Nelson, David, L. M. M. Cox. (2008).Principles of Biochemistry (ed.).New Yprk: W . H. Freeman and Company.

Nordin, G., A. Martensson, B. Swolin, S. Sandberg, N. J. Christensen, V. Thorsteinsson, L. Franzson, V. Kairisto and E. R. Savolainen (2004). "A multicentre study of reference intervals for haemoglobin, basic blood cell counts and erythrocyte indices in the adult population of the Nordic countries." Scand J Clin Lab Invest, **64**(4): 385-398.

Osborne, J. W. A. O. (2004). "The power of outliers (and why researchers should ALWAYS check for them." Practical Assessment, Research & Evaluation, **9**(6).

Palestinian Meteorology Center, " correspondence" (2013).

Parraguez, V. H., Urquieta, B., Perez, L., Castellaro, G., De los Reyes, v, Torres-Rovira, L., Gonzalez-Bulnes, A. (2013). Fertility in a high-altitude environment is compromised by luteal dysfunction: the relative roles of hypoxia and oxidative stress. Reprod Biol Endocrinol, 11, 24.

Pendse, S.,& Singh, A. K. (2005). Complications of chronic kidney disease: anemia, mineral metabolism, and cardiovascular disease. Med Clin North Am, 89,549-561.

Proytcheva, M. A. (2009). Issues in neonatal cellular analysis. Am J Clin Pathol, 131, 560-573.

Pustovalov, A. P.,& Voronkov, I. F. (1988). Effect of heparin and hypobaric hypoxia on the blood electrolyte composition, ATPase activity and the membrane charge of erythrocytes. Farmakol Toksikol, 51, 53-57.

Quatrini, U., A. L.,& Morici, G. (1993). Oxygen-haemoglobin dissociation curve in hypoxic rats of first or second generation. Clin Exp Pharmacol Physiol, 20, 269-274.

Quinto, L., Aponte, J. J., Menendez, C., Sacarlal, J., Aide, P., Espasa, M., …Alonso, P. L. (2006). Relationship between haemoglobin and haematocrit in the definition of anaemia. Trop Med Int Health, 11, 1295-1302.

Richalet, J. P., Souberbielle, J. C., Antezana, A. M., Dechaux, M., Le Trong, J. L., Bienvenu, A. , Zittoun, J. (1994). Control of erythropoiesis in humans during prolonged exposure to the altitude of 6,542 m. Am J Physiol, 266, 756-764.

Roshan, T. M., Rosline, H., Ahmed, S. A., Rapiaah, M., Wan Zaidah, A.,& Khattak, M. N. (2009). Hematological reference values of healthy Malaysian population. Int J Lab Hematol, 31, 505-512.

McCall, R. E.,& Tankersley, C. M. (2012). Phlebotomy Essentials (5th ed.). China: Lippincott Williams and Wilkins.

Salisbury, A. C., Amin, A. P., Reid, K. J., Wang, T. Y., Alexander, K. P., Chan, P. S., Kosiborod, M. (2012). Red blood cell indices and development of hospital-acquired anemia during acute myocardial infarction. Am J Cardiol, 109, 1104-1110.

Sandhaus, L. M.,& Meyer, P. (2002). How useful are CBC and reticulocyte reports to clinicians? Am J Clin Pathol, 118, 787-793.

Savourey, G., Launay, J. C., Besnard, Y., Guinet, A., Bourrilhon, C., Cabane, D., Cottet-Emard, J. M. (2004). Control of erythropoiesis after high altitude acclimatization. Eur J Appl Physiol, 93, 47-56.

Saxena, R., Katoch, S. C., Srinivas, U., Rao, S. ,& Anand, H. (2007). Impact of external haematology proficiency testing programme on quality of laboratories. Indian J Med Res, 126,428-432.

Schizas, A. M., Reid, R., & George, M. L. (2007). Can haematological indices predict positive findings at endoscopy in anaemic patients? Ann R Coll Surg Engl, 89, 221-225.

Schmidt, W. (2002). Effects of intermittent exposure to high altitude on blood volume and erythropoietic activity. High Alt Med Biol, 3, 167-176.

Sciacovelli, L., Secchiero, S., Zardo, L., Zaninotto, M.,& Plebani, M. (2006). External Quality Assessment: an effective tool for Clinical Governance in laboratory medicine. Clin Chem Lab Med, 44, 740-749.

Sharma, S. C. (1981). Platelet count in permanent residents of high altitude.Indian J Physiol Pharmacol, 25, 65-68.

Son, H. J., Kim, H. J., Kim, J. H., Ohno, H.,& Kim, C. K. (2012). Erythropoietin, 2,3 DPG, oxygen transport capacity, and altitude training in adolescent Alpine skiers. Aviat Space Environ Med, 83, 50-53.

Spicuzza, L. N., Casiraghi, A., Gamboa, C., Keyl, A., Schneider, A., Mori, F.,…Bernardi, L. (2004). Sleep related hypoxaemia and excessive erythrocytosis in Andean high-altitude natives. Eur Respir, 23(1): 41. 46.

Stohlman, F., & Brecher, G. (1957). Humoral regulation of erythropoiesis. III. Effect of exposure to simulated altitude. J Lab Clin Med, 49, 890-895.

Sultana, G. S., Haque, S. A., Sultana, T., & Ahmed, A. N. (2013). Value of Red Cell Distribution Width (RDW) and RBC Indices in the Detection of Iron Deficiency Anemia. Mymensingh Med J, 22,370-376.

Taylor, M. R., Holland, C. V., Spencer, R., Jackson, J. F., O'Connor, G. I., & O'Donnell, J. R. (1997). Haematological reference ranges for schoolchildren.Clin Lab Haematol, 19, 1-15.

Tefferi, A. (2001). Primary hematology (ed.). USA: Springer Science + Business Media, LLC.

Tefferi, A., Hanson, C. A., &Inwards, D. J. (2005). How to interpret and pursue an abnormal complete blood cell count in adults.Mayo Clin Proc, 80, 923-936.

Tessier-Marteau, Genevieve, A., F., Godon, A., Macchi, L.,& Zandecki, M. (2010). Automated hematology analysers and spurious counts. Part 1. Platelets. Ann Biol Clin (Paris), 68, 393-407.

Trowbridge, E. A., Reardon, D. M., Bradey, L., Hutchinson, D. & Warren, C. W. (1989). Automated haematology: construction of univariate reference ranges for blood cell count and size. Med Lab Sci, 46(1): 23-32.

Vij, A. G., Dutta, R.,& Satija, N. K. (2005). Acclimatization to oxidative stress at high altitude.High Alt Med Biol, 6, 301-310.

Wakeman, L., Al-Ismail, S., Benton, A., Beddall, A., Gibbs, A., Hartnell, S., Munro, R. (2007). Robust, routine haematology reference ranges for healthy adults. Int J Lab Hematol, 29(4): 279-283.

Weiss, G.,& Goodnough, L. T. (2005). Anemia of chronic disease. N Engl J Med, 352, 1011-1023.

West, J. B. (2004). The physiologic basis of high-altitude diseases. Ann Intern Med, 141, 789-800.

Windsor, J. S., & Rodway, G. W. (2007). Heights and haematology: the story of haemoglobin at altitude. Postgrad Med, 83(977): 148-151.

Zandecki, M., Genevieve, F., Gerard, J., & Godon, A. (2007). Spurious counts and spurious results on haematology analysers: a review. Part I: platelets. Int J Lab Hematol, 29, 4-20.

Annex

Annex IA: CBC results of the participants before exclusion of the outliers from two groups, where Place 1 means Jericho group and place 2 means Ramallah group.

#	Place	class	**WBC**	**RBC**	**Hgb**	**Hct**	**MCV**	**MCH**	**MCHC**	**PLT**	**RDW**
1	1.00	11.00	6.00	5.26	14.10	42.30	80.40	26.80	33.30	291.00	11.30
2	1.00	12.00	6.00	5.40	16.00	45.80	84.80	29.60	34.90	182.00	9.80
3	1.00	11.00	9.20	5.58	16.30	47.10	84.40	29.20	34.60	418.00	10.80
4	1.00	12.00	5.90	4.91	14.10	41.70	84.90	28.70	33.80	238.00	10.40
5	1.00	12.00	8.00	5.80	15.20	45.20	77.90	26.20	33.60	189.00	11.00
6	1.00	11.00	8.10	5.10	15.80	44.10	86.50	31.00	35.80	237.00	10.90
7	1.00	12.00	9.70	5.38	16.60	47.00	87.40	30.90	35.30	285.00	10.50
8	1.00	12.00	5.30	4.84	15.20	43.20	89.30	31.40	35.20	218.00	10.00
9	1.00	11.00	4.30	5.31	16.20	46.00	86.60	30.50	35.20	242.00	10.10
10	1.00	12.00	5.50	4.93	14.80	42.30	85.80	30.00	35.00	335.00	10.90
11	1.00	12.00	8.60	5.49	16.20	46.30	84.30	29.50	35.00	343.00	10.90
12	1.00	11.00	9.40	5.73	16.40	46.90	81.80	28.60	35.00	340.00	10.50
13	1.00	12.00	7.60	5.04	16.00	45.80	90.90	31.70	34.90	177.00	10.50
14	1.00	11.00	7.90	4.85	15.20	43.60	89.90	31.30	34.90	271.00	10.90
15	1.00	12.00	10.70	5.31	15.50	44.60	84.00	29.20	34.80	286.00	10.10
16	1.00	12.00	5.70	5.39	16.50	47.40	87.90	30.60	34.80	214.00	10.40
17	1.00	12.00	7.40	4.85	14.60	41.90	86.40	30.10	34.80	292.00	9.80
18	1.00	11.00	7.30	4.83	14.30	41.10	85.10	29.60	34.80	211.00	10.50
19	1.00	12.00	9.20	5.35	14.90	43.00	80.40	27.90	34.70	418.00	10.90
20	1.00	12.00	8.80	5.17	15.10	43.50	84.10	29.20	34.70	224.00	10.20
21	1.00	12.00	7.90	5.53	16.10	46.40	83.90	29.10	34.70	309.00	10.20
22	1.00	11.00	6.50	5.01	14.80	42.70	85.20	29.50	34.70	293.00	10.50
23	1.00	12.00	5.90	4.99	15.00	43.30	86.80	30.10	34.60	326.00	10.40
24	1.00	12.00	6.50	5.63	15.90	45.90	81.50	28.20	34.60	222.00	11.20
25	1.00	12.00	6.50	5.26	14.90	43.20	82.10	28.30	34.50	361.00	10.70
26	1.00	12.00	7.00	5.64	16.20	47.00	83.30	28.70	34.50	327.00	11.10
27	1.00	12.00	12.70	4.69	14.20	41.20	87.80	30.30	34.50	316.00	10.50
28	1.00	12.00	4.10	5.36	16.00	46.40	86.60	29.90	34.50	244.00	10.10
29	1.00	11.00	8.60	4.88	15.20	44.10	90.40	31.10	34.50	302.00	10.60

#	Place	class	**WBC**	**RBC**	**Hgb**	**Hct**	**MCV**	**MCH**	**MCHC**	**PLT**	**RDW**
30	1.00	12.00	7.00	5.31	15.50	45.10	84.90	29.20	34.40	261.00	10.30
31	1.00	12.00	6.30	5.30	15.80	45.90	86.60	29.80	34.40	266.00	10.30
32	1.00	12.00	5.80	4.50	13.90	40.40	89.80	30.90	34.40	291.00	10.30
33	1.00	11.00	5.70	5.04	14.50	42.10	83.50	28.80	34.40	202.00	10.40
34	1.00	11.00	8.20	5.53	15.70	45.70	82.60	28.40	34.40	230.00	10.90
35	1.00	11.00	6.00	4.45	13.60	39.50	88.80	30.60	34.40	410.00	10.40
36	1.00	12.00	5.10	5.50	16.00	46.60	84.70	29.10	34.30	214.00	10.40
37	1.00	12.00	6.40	5.02	15.40	44.90	89.40	30.70	34.30	249.00	11.20
38	1.00	12.00	7.00	5.38	15.10	44.00	81.80	28.10	34.30	308.00	10.50
39	1.00	12.00	8.30	4.79	13.60	39.60	82.70	28.40	34.30	322.00	11.00
40	1.00	12.00	9.60	5.19	15.10	44.00	84.80	29.10	34.30	242.00	10.80
41	1.00	12.00	5.60	4.82	14.60	42.60	88.40	30.30	34.30	244.00	10.50
42	1.00	12.00	6.50	5.34	15.40	44.90	84.10	28.80	34.30	265.00	10.50
43	1.00	11.00	6.30	4.82	14.20	41.40	85.90	29.50	34.30	277.00	11.00
44	1.00	11.00	7.70	4.85	15.10	44.00	90.70	31.10	34.30	337.00	10.50
45	1.00	12.00	5.50	5.04	14.20	41.50	82.30	28.20	34.20	183.00	10.40
46	1.00	12.00	4.80	5.39	16.30	47.70	88.50	30.20	34.20	334.00	10.50
47	1.00	12.00	7.00	5.24	15.00	44.00	84.00	28.60	34.10	318.00	10.30
48	1.00	12.00	5.10	5.23	14.50	42.50	81.30	27.70	34.10	371.00	10.80
49	1.00	12.00	7.30	5.34	15.00	44.00	82.40	28.10	34.10	278.00	10.60
50	1.00	11.00	6.30	4.69	13.90	40.80	87.00	29.60	34.10	232.00	11.00
51	1.00	11.00	3.60	4.90	14.50	42.50	86.70	29.60	34.10	251.00	10.10
52	1.00	12.00	6.50	5.11	15.00	44.10	86.30	29.40	34.00	317.00	10.70
53	1.00	12.00	6.80	5.33	15.40	45.30	85.00	28.90	34.00	320.00	11.00
54	1.00	12.00	8.90	4.99	14.80	43.60	87.40	29.70	33.90	377.00	10.50
55	1.00	11.00	6.80	5.60	15.30	45.10	80.50	27.30	33.90	231.00	10.60
56	1.00	12.00	5.00	5.05	14.80	43.80	86.70	29.30	33.80	226.00	10.60
57	1.00	12.00	5.60	5.58	15.30	45.30	81.20	27.40	33.80	199.00	10.50
58	1.00	12.00	6.90	4.78	14.20	42.00	87.90	29.70	33.80	260.00	10.70
59	1.00	11.00	7.30	4.61	13.90	41.10	89.20	30.20	33.80	435.00	10.90
60	1.00	11.00	5.10	5.57	16.10	47.70	85.60	28.90	33.80	340.00	10.10
61	1.00	11.00	6.20	4.86	14.10	41.70	85.80	29.00	33.80	237.00	11.10
62	1.00	12.00	5.50	4.62	12.60	37.40	81.00	27.30	33.70	322.00	10.30

#	Place	class	**WBC**	**RBC**	**Hgb**	**Hct**	**MCV**	**MCH**	**MCHC**	**PLT**	**RDW**
63	1.00	12.00	10.50	5.27	14.20	42.10	79.90	26.90	33.70	354.00	10.80
64	1.00	12.00	8.30	5.18	14.20	42.10	81.30	27.40	33.70	365.00	10.20
65	1.00	12.00	6.20	5.27	14.70	43.60	82.70	27.90	33.70	278.00	10.30
66	1.00	12.00	6.80	5.46	14.50	43.00	78.80	26.60	33.70	274.00	10.70
67	1.00	12.00	6.40	5.69	16.00	47.60	83.70	28.10	33.60	270.00	10.40
68	1.00	12.00	6.70	4.91	14.70	43.80	89.20	29.90	33.60	218.00	10.40
69	1.00	12.00	7.80	5.34	15.00	44.80	83.90	28.10	33.50	246.00	9.70
70	1.00	12.00	7.40	4.60	12.80	38.20	83.00	27.80	33.50	179.00	12.40
71	1.00	12.00	6.20	5.13	13.90	41.80	81.50	27.10	33.30	301.00	10.50
72	1.00	12.00	8.40	5.09	15.00	45.10	88.60	29.50	33.30	262.00	9.90
73	1.00	12.00	5.80	6.06	16.20	48.70	80.40	26.70	33.30	226.00	10.30
74	1.00	12.00	7.90	5.70	14.40	43.20	75.80	25.30	33.30	420.00	10.80
75	1.00	12.00	7.30	5.37	15.60	46.80	87.20	29.10	33.30	250.00	10.20
76	1.00	12.00	7.90	5.61	14.40	43.60	77.70	25.70	33.00	233.00	11.00
77	1.00	11.00	5.10	4.93	13.50	40.90	83.00	27.40	33.00	288.00	9.90
78	1.00	11.00	9.30	5.83	14.80	44.90	77.00	25.40	33.00	302.00	10.60
79	1.00	12.00	6.20	5.28	14.80	45.00	85.20	28.00	32.90	342.00	10.10
80	1.00	11.00	8.70	6.10	15.50	47.50	77.90	25.40	32.60	297.00	10.80
81	1.00	12.00	8.30	5.13	13.80	42.40	82.70	26.90	32.50	432.00	10.40
82	1.00	12.00	6.50	5.48	13.90	42.80	78.10	25.40	32.50	229.00	10.60
83	1.00	12.00	7.80	5.69	12.80	40.00	70.30	22.50	32.00	203.00	11.50
84	1.00	11.00	8.60	5.09	12.00	37.50	73.70	23.60	32.00	279.00	10.30
85	1.00	12.00	9.30	6.82	13.40	42.00	61.60	19.60	31.90	375.00	14.00
86	1.00	11.00	8.10	6.28	13.40	42.40	67.50	21.30	31.60	333.00	11.10
87	1.00	12.00	4.80	6.07	13.30	42.50	70.00	21.90	31.30	285.00	10.30
88	1.00	11.00	6.90	6.22	11.60	37.40	60.10	18.60	31.00	318.00	11.40
89	1.00	11.00	4.10	5.28	16.10	45.30	85.80	30.50	35.50	202.00	11.00
90	1.00	11.00	7.20	5.71	17.20	48.70	85.30	30.10	35.30	180.00	10.80
91	1.00	12.00	6.50	5.66	16.70	47.50	83.90	29.50	35.20	281.00	11.00
92	1.00	11.00	10.00	4.89	13.60	38.70	79.10	27.80	35.10	350.00	10.60
93	1.00	11.00	5.70	4.87	14.70	42.00	86.20	30.20	35.00	292.00	10.70
94	1.00	11.00	6.50	5.12	14.70	42.20	82.40	28.70	34.80	409.00	11.00
95	1.00	11.00	17.70	5.22	15.50	44.60	85.40	29.70	34.80	296.00	10.50

#	Place	class	**WBC**	**RBC**	**Hgb**	**Hct**	**MCV**	**MCH**	**MCHC**	**PLT**	**RDW**
96	1.00	11.00	5.10	5.05	13.70	39.50	78.20	27.10	34.70	327.00	11.20
97	1.00	11.00	7.70	5.52	16.50	47.50	86.10	29.90	34.70	287.00	10.40
98	1.00	11.00	6.90	5.22	15.90	46.00	88.10	30.50	34.60	212.00	10.90
99	1.00	11.00	10.60	5.33	15.60	45.20	84.80	29.30	34.50	265.00	10.30
100	1.00	11.00	5.30	4.67	13.90	40.30	86.30	29.80	34.50	283.00	10.40
101	1.00	11.00	6.60	4.71	14.50	42.00	89.20	30.80	34.50	203.00	10.50
102	1.00	12.00	7.10	4.63	13.80	40.10	86.60	29.80	34.40	233.00	10.70
103	1.00	11.00	5.60	5.44	15.50	45.10	82.90	28.50	34.40	348.00	10.30
104	1.00	11.00	5.90	5.79	17.50	50.80	87.70	30.20	34.40	261.00	10.50
105	1.00	11.00	9.70	5.24	15.60	45.40	86.60	29.80	34.40	342.00	10.70
106	1.00	11.00	6.70	4.86	14.70	42.80	88.10	30.20	34.30	256.00	10.40
107	1.00	11.00	10.80	5.25	15.50	45.20	86.10	29.50	34.30	362.00	10.40
108	1.00	12.00	7.30	5.13	13.80	40.40	78.80	26.90	34.20	260.00	11.00
109	1.00	11.00	8.00	5.31	15.30	44.70	84.20	28.80	34.20	300.00	10.40
110	1.00	11.00	7.00	5.51	15.30	44.70	81.10	27.80	34.20	299.00	10.70
111	1.00	11.00	9.60	5.46	15.60	45.60	83.50	28.60	34.20	224.00	10.80
112	1.00	11.00	5.30	5.13	15.30	44.70	87.10	29.80	34.20	210.00	10.50
113	1.00	11.00	4.40	5.14	15.20	44.50	86.60	29.60	34.20	326.00	10.00
114	1.00	11.00	12.40	5.63	16.60	48.50	86.10	29.50	34.20	346.00	10.60
115	1.00	11.00	7.00	4.81	14.30	41.90	87.10	29.70	34.10	164.00	10.70
116	1.00	11.00	5.60	5.00	15.00	44.00	88.00	30.00	34.10	295.00	10.40
117	1.00	11.00	6.50	4.52	14.00	41.10	90.90	31.00	34.10	302.00	10.10
118	1.00	12.00	6.50	4.51	12.80	37.60	83.40	28.40	34.00	368.00	10.70
119	1.00	11.00	7.10	5.04	14.20	41.80	82.90	28.20	34.00	368.00	10.70
120	1.00	11.00	6.70	5.78	16.70	49.30	85.30	28.90	33.90	380.00	10.30
121	1.00	11.00	9.40	5.36	14.70	43.30	80.80	27.40	33.90	353.00	12.20
122	1.00	12.00	8.60	5.18	15.40	45.60	88.00	29.70	33.80	307.00	9.80
123	1.00	12.00	8.00	4.50	14.00	41.40	92.00	31.10	33.80	314.00	9.80
124	1.00	11.00	4.30	5.43	15.50	45.80	84.30	28.50	33.80	217.00	10.80
125	1.00	11.00	9.20	4.88	14.00	41.40	84.80	28.70	33.80	466.00	10.20
126	1.00	11.00	5.40	4.83	13.80	40.80	84.50	28.60	33.80	255.00	10.20
127	1.00	11.00	8.80	5.27	13.60	40.40	76.70	25.80	33.70	385.00	10.80
128	1.00	11.00	10.50	5.42	14.30	42.40	78.20	26.40	33.70	442.00	11.80

#	Place	class	**WBC**	**RBC**	**Hgb**	**Hct**	**MCV**	**MCH**	**MCHC**	**PLT**	**RDW**
129	1.00	12.00	4.50	4.92	14.00	41.70	84.80	28.50	33.60	309.00	10.30
130	1.00	11.00	6.40	5.18	14.30	42.60	82.20	27.60	33.60	235.00	10.20
131	1.00	11.00	6.50	4.89	14.40	42.80	87.50	29.40	33.60	237.00	10.50
132	1.00	11.00	9.10	4.97	14.70	43.80	88.10	29.60	33.60	465.00	10.70
133	1.00	11.00	6.10	4.57	14.00	41.80	91.50	30.60	33.50	196.00	9.70
134	1.00	11.00	6.20	5.14	13.00	38.80	75.50	25.30	33.50	408.00	11.30
135	1.00	11.00	6.60	5.49	14.40	43.00	78.30	26.20	33.50	301.00	10.60
136	1.00	11.00	8.30	5.85	16.00	47.90	81.90	27.40	33.40	296.00	9.90
137	1.00	11.00	8.30	5.40	13.40	40.30	74.60	24.80	33.30	316.00	11.50
138	1.00	11.00	8.80	5.52	14.70	44.10	79.90	26.60	33.30	372.00	10.50
139	1.00	11.00	7.60	5.04	14.60	43.80	86.90	29.00	33.30	315.00	10.90
140	1.00	11.00	6.70	5.59	15.70	47.10	84.30	28.10	33.30	340.00	11.00
141	1.00	11.00	6.30	5.10	13.00	39.30	77.10	25.50	33.10	433.00	11.60
142	1.00	11.00	6.20	5.77	14.70	44.60	77.30	25.50	33.00	370.00	11.80
143	1.00	11.00	6.50	5.81	14.60	44.40	76.40	25.10	32.90	223.00	10.90
144	1.00	11.00	4.50	5.44	14.00	42.70	78.50	25.70	32.80	225.00	11.60
145	1.00	11.00	14.90	4.83	12.30	37.50	77.60	25.50	32.80	352.00	12.20
146	1.00	11.00	10.60	5.54	13.10	40.20	72.60	23.60	32.60	477.00	14.60
147	1.00	11.00	14.70	5.51	12.00	37.30	67.70	21.80	32.20	358.00	13.10
148	1.00	11.00	10.20	7.13	13.30	42.10	59.00	18.70	31.60	359.00	12.50
149	1.00	11.00	8.80	6.33	12.20	39.80	62.90	19.30	30.70	269.00	12.70
150	1.00	11.00	7.60	6.51	12.60	41.70	64.10	19.40	30.20	387.00	12.00
151	1.00	12.00	5.20	4.79	8.30	28.50	59.50	17.30	29.10	441.00	14.50
152	1.00	11.00	7.80	5.43	16.10	46.20	85.10	29.70	34.80	315.00	10.70
153	1.00	11.00	4.40	4.86	15.50	45.10	92.80	31.90	34.40	185.00	10.30
154	1.00	11.00	5.40	4.71	13.10	38.20	81.10	27.80	34.30	283.00	10.80
155	1.00	11.00	7.30	5.06	15.10	44.10	87.20	29.80	34.20	205.00	10.70
156	1.00	11.00	11.90	5.54	16.20	47.60	85.90	29.20	34.00	340.00	10.30
157	1.00	11.00	7.50	4.80	13.40	39.50	82.30	27.90	33.90	239.00	11.00
158	1.00	11.00	6.50	5.51	16.00	46.30	85.80	29.00	33.80	253.00	10.70
159	1.00	11.00	8.90	4.77	13.60	40.20	84.30	28.50	33.80	398.00	10.40
160	1.00	11.00	8.10	4.97	14.40	42.80	86.10	29.00	33.60	321.00	11.60
161	1.00	11.00	7.40	5.33	15.20	45.20	84.80	28.50	33.60	257.00	10.80

#	Place	class	**WBC**	**RBC**	**Hgb**	**Hct**	**MCV**	**MCH**	**MCHC**	**PLT**	**RDW**
162	1.00	11.00	7.70	5.95	14.90	44.80	75.30	25.00	33.30	362.00	11.90
163	2.00	12.00	8.46	5.69	16.60	47.90	84.20	29.20	34.70	392.00	10.10
164	2.00	12.00	7.50	5.92	16.90	48.80	82.40	28.50	34.60	229.00	10.90
165	2.00	12.00	7.10	5.72	14.50	44.40	77.60	25.30	32.70	257.00	11.80
166	2.00	12.00	5.60	4.86	15.30	43.40	89.30	31.50	35.30	279.00	10.50
167	2.00	12.00	12.50	5.20	16.30	46.40	89.20	31.30	35.10	345.00	9.70
168	2.00	12.00	7.60	6.17	18.40	52.60	85.30	29.80	35.00	236.00	10.60
169	2.00	12.00	8.00	5.36	16.00	45.70	85.30	29.90	35.00	128.00	10.30
170	2.00	12.00	8.70	5.73	16.40	46.90	81.80	28.60	35.00	168.00	11.10
171	2.00	12.00	5.50	5.55	16.10	46.30	83.40	29.00	34.80	317.00	10.90
172	2.00	12.00	7.80	5.47	15.40	44.40	81.20	28.20	34.70	272.00	10.40
173	2.00	12.00	8.00	6.09	18.10	52.10	85.60	29.70	34.70	263.00	10.80
174	2.00	12.00	8.40	5.43	15.90	45.90	84.50	29.30	34.60	247.00	11.80
175	2.00	12.00	16.10	5.64	17.30	50.00	88.70	30.70	34.60	270.00	10.20
176	2.00	12.00	6.20	5.12	14.90	43.10	84.20	29.10	34.60	232.00	10.30
177	2.00	12.00	6.40	5.40	15.70	45.50	84.30	29.10	34.50	339.00	10.50
178	2.00	12.00	7.60	5.34	16.50	47.80	89.50	30.90	34.50	301.00	10.60
179	2.00	12.00	5.50	4.82	14.90	43.20	89.60	30.90	34.50	254.00	10.30
180	2.00	12.00	6.30	5.36	15.40	44.70	83.40	28.70	34.50	247.00	10.90
181	2.00	12.00	7.50	5.64	15.90	46.10	81.70	28.20	34.50	191.00	10.60
182	2.00	12.00	7.80	5.57	15.80	45.80	82.20	28.40	34.50	249.00	10.80
183	2.00	12.00	6.90	5.17	15.10	43.70	84.70	29.20	34.50	294.00	10.20
184	2.00	12.00	3.80	5.32	15.40	44.60	83.80	28.90	34.50	268.00	11.20
185	2.00	12.00	5.80	5.11	15.80	45.80	89.60	30.90	34.50	301.00	10.30
186	2.00	11.00	5.90	4.71	14.10	41.00	87.00	29.90	34.40	218.00	10.30
187	2.00	12.00	7.10	5.40	16.50	48.10	89.10	30.60	34.30	234.00	10.40
188	2.00	12.00	7.50	6.13	17.10	49.80	81.20	27.90	34.30	229.00	10.70
189	2.00	12.00	5.00	5.04	15.80	46.10	91.50	31.30	34.30	222.00	10.30
190	2.00	12.00	6.00	5.07	15.70	45.80	90.30	31.00	34.30	249.00	10.20
191	2.00	11.00	7.80	5.03	14.60	42.60	84.70	29.00	34.30	367.00	10.70
192	2.00	12.00	9.10	5.59	15.90	46.50	83.20	28.40	34.20	231.00	10.20
193	2.00	12.00	10.20	5.32	15.30	44.80	84.20	28.80	34.20	311.00	10.00
194	2.00	11.00	8.30	4.56	13.90	40.70	89.30	30.50	34.20	220.00	10.60

#	Place	class	**WBC**	**RBC**	**Hgb**	**Hct**	**MCV**	**MCH**	**MCHC**	**PLT**	**RDW**
195	2.00	12.00	7.10	6.09	17.70	51.90	85.20	29.10	34.10	213.00	10.60
196	2.00	12.00	9.80	5.55	15.50	45.50	82.00	27.90	34.10	337.00	10.80
197	2.00	12.00	8.20	5.02	14.80	43.40	86.50	29.50	34.10	321.00	10.20
198	2.00	12.00	9.00	5.48	16.20	47.50	86.70	29.60	34.10	318.00	10.00
199	2.00	12.00	10.90	5.27	15.40	45.30	86.00	29.20	34.00	375.00	10.50
200	2.00	12.00	8.40	5.39	15.30	45.00	83.50	28.40	34.00	222.00	10.50
201	2.00	12.00	6.80	5.36	15.20	44.70	83.40	28.40	34.00	270.00	10.80
202	2.00	12.00	4.40	5.37	14.80	43.50	81.00	27.60	34.00	316.00	11.20
203	2.00	12.00	5.60	5.33	14.90	44.00	82.60	28.00	33.90	339.00	10.50
204	2.00	12.00	11.30	5.55	15.00	44.20	79.60	27.00	33.90	232.00	11.90
205	2.00	12.00	5.00	4.40	12.90	38.10	86.60	29.30	33.90	273.00	11.20
206	2.00	12.00	3.40	4.73	13.90	41.10	86.90	29.40	33.80	249.00	10.00
207	2.00	12.00	8.10	5.27	16.30	48.30	91.70	30.90	33.70	215.00	10.20
208	2.00	12.00	6.00	5.46	14.50	43.00	78.80	26.60	33.70	265.00	10.00
209	2.00	12.00	7.40	6.18	15.90	47.20	76.40	25.70	33.70	271.00	11.00
210	2.00	12.00	6.30	5.78	14.40	42.70	73.90	24.90	33.70	223.00	11.20
211	2.00	11.00	9.90	5.45	15.60	46.40	85.10	28.60	33.60	264.00	11.10
212	2.00	12.00	10.10	5.36	16.00	47.70	89.00	29.90	33.50	308.00	9.90
213	2.00	12.00	7.40	5.62	15.20	45.50	81.00	27.00	33.40	268.00	10.90
214	2.00	12.00	7.60	5.58	15.80	47.40	84.90	28.30	33.30	274.00	10.30
215	2.00	12.00	4.20	5.03	13.00	39.10	77.70	25.80	33.20	252.00	11.20
216	2.00	12.00	10.50	6.28	15.90	48.10	76.60	25.30	33.10	312.00	11.10
217	2.00	12.00	4.70	6.36	12.90	39.80	62.60	20.30	32.40	301.00	12.50
218	2.00	12.00	6.80	6.78	14.30	44.50	65.60	21.10	32.10	277.00	15.40
219	2.00	11.00	6.70	5.21	15.70	45.10	86.60	30.10	34.80	300.00	10.30
220	2.00	11.00	7.20	5.06	16.00	45.00	88.90	31.60	35.60	256.00	10.60
221	2.00	11.00	7.40	4.86	14.70	41.50	85.40	30.20	35.40	286.00	10.40
222	2.00	11.00	7.50	4.97	15.00	42.40	85.30	30.20	35.40	244.00	10.60
223	2.00	11.00	7.60	5.30	16.60	46.90	88.50	31.30	35.40	240.00	10.30
224	2.00	11.00	6.80	5.35	15.80	44.90	83.90	29.50	35.20	210.00	11.50
225	2.00	12.00	5.50	4.48	14.40	41.20	92.00	32.10	35.00	236.00	9.90
226	2.00	11.00	6.40	5.25	15.90	45.40	86.50	30.30	35.00	237.00	10.50
227	2.00	11.00	7.10	5.88	16.70	47.90	81.50	28.40	34.90	300.00	10.50

#	Place	class	**WBC**	**RBC**	**Hgb**	**Hct**	**MCV**	**MCH**	**MCHC**	**PLT**	**RDW**
228	2.00	11.00	5.40	5.64	16.30	46.70	82.80	28.90	34.90	246.00	10.80
229	2.00	12.00	7.20	5.68	16.90	48.60	85.60	29.80	34.80	197.00	10.20
230	2.00	12.00	7.40	5.65	16.90	48.70	86.20	29.90	34.70	240.00	10.40
231	2.00	12.00	8.90	5.00	15.70	45.20	90.40	31.40	34.70	290.00	10.50
232	2.00	11.00	6.20	4.82	14.40	41.50	86.10	29.90	34.70	214.00	10.90
233	2.00	11.00	6.90	5.40	15.30	44.10	81.70	28.30	34.70	214.00	10.90
234	2.00	11.00	8.30	4.99	15.40	44.40	89.00	30.90	34.70	282.00	10.10
235	2.00	11.00	7.30	5.66	15.40	44.40	78.40	27.20	34.70	173.00	13.70
236	2.00	11.00	6.30	5.41	15.60	45.10	83.40	28.80	34.60	197.00	10.80
237	2.00	11.00	10.20	4.93	14.20	41.00	83.20	28.80	34.60	250.00	10.50
238	2.00	11.00	11.50	5.23	14.70	42.50	81.30	28.10	34.60	288.00	10.50
239	2.00	11.00	5.20	5.63	16.00	46.20	82.10	28.40	34.60	258.00	10.70
240	2.00	11.00	8.50	5.00	15.10	43.70	87.40	30.20	34.60	365.00	10.70
241	2.00	11.00	7.10	5.32	15.70	45.40	85.30	29.50	34.60	238.00	10.50
242	2.00	11.00	5.10	4.71	14.30	41.30	87.76	30.40	34.60	155.00	10.80
243	2.00	11.00	7.80	5.07	15.20	44.00	86.80	30.00	34.50	245.00	11.10
244	2.00	11.00	5.40	4.73	14.30	41.00	87.70	30.20	34.50	165.00	10.70
245	2.00	11.00	7.20	5.18	15.30	44.40	85.70	29.50	34.50	252.00	10.30
246	2.00	11.00	7.70	5.65	16.20	46.90	83.00	28.70	34.50	254.00	11.00
247	2.00	11.00	6.20	5.29	15.40	44.60	84.30	29.10	34.50	308.00	11.00
248	2.00	12.00	5.80	5.43	15.60	46.20	83.70	28.20	34.40	188.00	10.40
249	2.00	11.00	8.90	5.98	17.10	49.70	83.10	28.60	34.40	225.00	10.60
250	2.00	11.00	7.10	5.49	16.40	47.70	86.90	29.90	34.40	263.00	10.60
251	2.00	11.00	7.00	5.01	14.40	41.80	83.40	28.70	34.40	276.00	11.00
252	2.00	11.00	4.90	5.34	15.70	45.60	85.40	29.40	34.40	232.00	10.30
253	2.00	11.00	6.00	5.20	15.30	44.50	85.60	29.40	34.40	261.00	10.40
254	2.00	11.00	7.00	5.54	16.50	48.10	86.80	29.80	34.30	264.00	10.20
255	2.00	11.00	6.00	5.58	15.90	46.30	83.00	28.50	34.30	189.00	11.00
256	2.00	12.00	6.00	5.61	16.00	46.80	83.40	28.50	34.20	251.00	10.70
257	2.00	11.00	5.20	5.28	14.90	43.60	82.60	28.20	34.20	309.00	11.50
258	2.00	11.00	9.10	5.64	15.20	44.50	78.90	27.00	34.20	288.00	10.20
259	2.00	11.00	6.70	5.30	15.10	44.10	83.20	28.50	34.20	232.00	10.10
260	2.00	11.00	7.20	5.30	14.20	41.50	78.30	26.80	34.20	268.00	10.60

#	Place	class	**WBC**	**RBC**	**Hgb**	**Hct**	**MCV**	**MCH**	**MCHC**	**PLT**	**RDW**
261	2.00	12.00	5.60	5.47	15.60	45.80	83.70	28.50	34.10	178.00	10.60
262	2.00	12.00	6.70	5.73	16.00	47.00	82.00	27.90	34.00	238.00	10.90
263	2.00	12.00	4.60	5.43	14.60	43.00	79.20	26.90	34.00	196.00	10.70
264	2.00	12.00	5.50	5.61	16.00	47.10	84.00	28.50	34.00	325.00	9.90
265	2.00	11.00	7.30	5.38	14.80	43.50	80.90	27.50	34.00	266.00	10.70
266	2.00	11.00	7.20	4.94	14.70	43.20	87.40	29.80	34.00	285.00	10.40
267	2.00	11.00	7.20	5.35	16.10	47.30	88.40	30.10	34.00	229.00	10.70
268	2.00	11.00	6.30	5.04	14.80	43.50	86.30	29.40	34.00	295.00	10.70
269	2.00	11.00	8.70	4.89	14.30	42.10	86.10	29.20	34.00	336.00	10.50
270	2.00	11.00	5.90	5.53	16.20	47.60	86.10	29.30	34.00	133.00	11.00
271	2.00	11.00	7.60	5.22	14.70	43.20	82.80	28.20	34.00	209.00	11.00
272	2.00	11.00	7.20	4.92	14.40	42.40	86.20	29.30	34.00	310.00	10.50
273	2.00	12.00	6.00	5.21	15.30	45.10	86.60	29.40	33.90	283.00	10.40
274	2.00	12.00	8.50	4.67	13.70	40.40	86.50	29.30	33.90	301.00	10.40
275	2.00	11.00	9.30	5.17	14.80	43.60	84.30	28.60	33.90	272.00	10.60
276	2.00	11.00	5.70	5.35	15.70	46.30	86.50	29.30	33.90	232.00	10.20
277	2.00	11.00	7.00	5.08	14.80	43.70	86.00	29.10	33.90	270.00	10.70
278	2.00	11.00	7.40	4.84	14.00	41.30	85.30	28.90	33.90	304.00	11.20
279	2.00	11.00	6.70	4.86	14.50	42.80	88.10	29.80	33.90	304.00	10.80
280	2.00	11.00	5.80	5.47	16.10	47.50	86.80	29.40	33.90	295.00	10.20
281	2.00	11.00	4.40	5.39	14.90	44.00	81.60	27.60	33.90	174.00	10.50
282	2.00	11.00	5.60	5.17	14.40	42.60	82.40	27.90	33.80	355.00	10.80
283	2.00	11.00	5.90	5.29	15.50	45.80	86.60	29.30	33.80	278.00	10.80
284	2.00	11.00	7.40	5.73	15.30	45.30	79.10	26.70	33.80	282.00	10.50
285	2.00	11.00	6.90	4.84	13.40	39.60	81.80	27.70	33.80	253.00	10.80
286	2.00	11.00	9.20	5.59	15.60	46.20	82.60	27.90	33.80	142.00	11.10
287	2.00	11.00	6.40	4.93	14.00	41.40	84.00	28.40	33.80	368.00	10.40
288	2.00	11.00	6.10	5.25	14.80	43.80	83.40	28.20	33.80	181.00	11.00
289	2.00	11.00	7.10	5.05	14.30	42.30	83.80	28.30	33.80	277.00	10.80
290	2.00	11.00	5.70	4.73	13.30	39.40	83.30	28.10	33.80	315.00	10.60
291	2.00	11.00	5.40	5.00	13.90	41.20	82.40	27.80	33.70	175.00	11.40
292	2.00	11.00	6.00	5.26	14.40	42.80	81.40	27.40	33.60	164.00	10.50
293	2.00	11.00	9.70	6.11	15.80	47.20	77.30	25.90	33.50	444.00	10.80

#	Place	class	**WBC**	**RBC**	**Hgb**	**Hct**	**MCV**	**MCH**	**MCHC**	**PLT**	**RDW**
294	2.00	11.00	6.20	5.35	15.20	45.40	84.90	28.40	33.50	282.00	10.50
295	2.00	11.00	9.50	5.24	14.60	43.60	83.20	27.90	33.50	269.00	11.30
296	2.00	11.00	6.40	5.72	15.20	45.40	79.40	26.60	33.50	289.00	10.80
297	2.00	12.00	6.80	6.00	15.80	47.30	78.80	26.30	33.40	318.00	10.20
298	2.00	11.00	10.60	5.22	14.70	44.00	84.30	28.20	33.40	204.00	11.30
299	2.00	11.00	4.60	5.73	12.70	38.20	66.70	22.20	33.20	344.00	12.50
300	2.00	11.00	7.10	5.09	12.00	36.40	71.50	23.60	33.00	255.00	13.20
301	2.00	11.00	6.10	4.98	13.80	41.90	84.10	27.70	32.90	227.00	10.90
302	2.00	11.00	6.00	5.71	12.80	39.10	68.50	22.40	32.70	201.00	11.70
303	2.00	11.00	6.60	4.92	13.30	40.80	82.90	27.00	32.60	195.00	10.20
304	2.00	11.00	4.90	5.57	13.60	41.80	75.00	24.40	32.50	214.00	10.80
305	2.00	11.00	7.60	6.19	14.30	44.60	72.10	23.10	32.10	211.00	11.70
306	2.00	11.00	8.70	7.22	13.10	42.00	58.20	18.10	31.20	181.00	13.00
307	2.00	11.00	7.50	5.48	15.30	43.70	79.70	27.90	35.00	311.00	10.70
308	2.00	11.00	6.70	5.52	16.00	45.90	83.20	29.00	34.90	299.00	10.70
309	2.00	11.00	6.40	5.65	16.30	46.80	82.80	28.80	34.80	243.00	10.70
310	2.00	12.00	7.30	4.88	15.10	43.70	89.50	30.90	34.60	255.00	10.40
311	2.00	11.00	6.70	5.18	15.50	44.80	86.50	29.90	34.60	251.00	10.30
312	2.00	11.00	4.10	5.55	15.30	44.50	80.20	27.60	34.40	232.00	10.60
313	2.00	11.00	5.00	5.19	15.30	44.60	85.90	29.50	34.30	216.00	9.90
314	2.00	11.00	7.20	4.99	14.60	42.60	85.40	29.30	34.30	388.00	10.60
315	2.00	11.00	5.20	5.01	14.00	40.90	81.60	27.90	34.20	177.00	10.70
316	2.00	11.00	5.80	4.83	14.80	43.40	89.90	30.60	34.10	228.00	10.70
317	2.00	11.00	7.00	4.98	14.30	42.10	84.50	28.70	34.00	291.00	10.90
318	2.00	11.00	6.20	5.23	14.20	41.90	80.10	27.20	33.90	363.00	10.10
319	2.00	11.00	4.00	5.88	16.20	48.40	82.30	27.60	33.50	240.00	10.80
320	2.00	11.00	5.20	5.34	14.60	43.80	82.00	27.30	33.30	271.00	10.60

Annex IB: CBC results of the participants after exclusion of the outliers from two groups where Place 1 means Jericho group and place 2 means Ramallah group.

#	Place	class	**WBC**	**RBC**	**Hgb**	**Hct**	**MCV**	**MCH**	**MCHC**	**PLT**	**RDW**
1	1.00	11.00	6.00	5.26	14.10	42.30	80.40	26.80	33.30	291.00	11.30
2	1.00	12.00	6.00	5.40	16.00	45.80	84.80	29.60	34.90	182.00	9.80
3	1.00	11.00	9.20	5.58	16.30	47.10	84.40	29.20	34.60	418.00	10.80
4	1.00	12.00	5.90	4.91	14.10	41.70	84.90	28.70	33.80	238.00	10.40
5	1.00	12.00	8.00	5.80	15.20	45.20	77.90	26.20	33.60	189.00	11.00
6	1.00	11.00	8.10	5.10	15.80	44.10	86.50	31.00	35.80	237.00	10.90
7	1.00	12.00	9.70	5.38	16.60	47.00	87.40	30.90	35.30	285.00	10.50
8	1.00	12.00	5.30	4.84	15.20	43.20	89.30	31.40	35.20	218.00	10.00
9	1.00	11.00	4.30	5.31	16.20	46.00	86.60	30.50	35.20	242.00	10.10
10	1.00	12.00	5.50	4.93	14.80	42.30	85.80	30.00	35.00	335.00	10.90
11	1.00	12.00	8.60	5.49	16.20	46.30	84.30	29.50	35.00	343.00	10.90
12	1.00	11.00	9.40	5.73	16.40	46.90	81.80	28.60	35.00	340.00	10.50
13	1.00	12.00	7.60	5.04	16.00	45.80	90.90	31.70	34.90	177.00	10.50
14	1.00	11.00	7.90	4.85	15.20	43.60	89.90	31.30	34.90	271.00	10.90
15	1.00	12.00	10.70	5.31	15.50	44.60	84.00	29.20	34.80	286.00	10.10
16	1.00	12.00	5.70	5.39	16.50	47.40	87.90	30.60	34.80	214.00	10.40
17	1.00	12.00	7.40	4.85	14.60	41.90	86.40	30.10	34.80	292.00	9.80
18	1.00	11.00	7.30	4.83	14.30	41.10	85.10	29.60	34.80	211.00	10.50
19	1.00	12.00	9.20	5.35	14.90	43.00	80.40	27.90	34.70	418.00	10.90
20	1.00	12.00	8.80	5.17	15.10	43.50	84.10	29.20	34.70	224.00	10.20
21	1.00	12.00	7.90	5.53	16.10	46.40	83.90	29.10	34.70	309.00	10.20
22	1.00	11.00	6.50	5.01	14.80	42.70	85.20	29.50	34.70	293.00	10.50
23	1.00	12.00	5.90	4.99	15.00	43.30	86.80	30.10	34.60	326.00	10.40
24	1.00	12.00	6.50	5.63	15.90	45.90	81.50	28.20	34.60	222.00	11.20
25	1.00	12.00	6.50	5.26	14.90	43.20	82.10	28.30	34.50	361.00	10.70
26	1.00	12.00	7.00	5.64	16.20	47.00	83.30	28.70	34.50	327.00	11.10
27	1.00	12.00	12.70	4.69	14.20	41.20	87.80	30.30	34.50	316.00	10.50
28	1.00	12.00	4.10	5.36	16.00	46.40	86.60	29.90	34.50	244.00	10.10
29	1.00	11.00	8.60	4.88	15.20	44.10	90.40	31.10	34.50	302.00	10.60
30	1.00	12.00	7.00	5.31	15.50	45.10	84.90	29.20	34.40	261.00	10.30
31	1.00	12.00	6.30	5.30	15.80	45.90	86.60	29.80	34.40	266.00	10.30

#	Place	class	**WBC**	**RBC**	**Hgb**	**Hct**	**MCV**	**MCH**	**MCHC**	**PLT**	**RDW**
32	1.00	12.00	5.80	4.50	13.90	40.40	89.80	30.90	34.40	291.00	10.30
33	1.00	11.00	5.70	5.04	14.50	42.10	83.50	28.80	34.40	202.00	10.40
34	1.00	11.00	8.20	5.53	15.70	45.70	82.60	28.40	34.40	230.00	10.90
35	1.00	11.00	6.00	4.45	13.60	39.50	88.80	30.60	34.40	410.00	10.40
36	1.00	12.00	5.10	5.50	16.00	46.60	84.70	29.10	34.30	214.00	10.40
37	1.00	12.00	6.40	5.02	15.40	44.90	89.40	30.70	34.30	249.00	11.20
38	1.00	12.00	7.00	5.38	15.10	44.00	81.80	28.10	34.30	308.00	10.50
39	1.00	12.00	8.30	4.79	13.60	39.60	82.70	28.40	34.30	322.00	11.00
40	1.00	12.00	9.60	5.19	15.10	44.00	84.80	29.10	34.30	242.00	10.80
41	1.00	12.00	5.60	4.82	14.60	42.60	88.40	30.30	34.30	244.00	10.50
42	1.00	12.00	6.50	5.34	15.40	44.90	84.10	28.80	34.30	265.00	10.50
43	1.00	11.00	6.30	4.82	14.20	41.40	85.90	29.50	34.30	277.00	11.00
44	1.00	11.00	7.70	4.85	15.10	44.00	90.70	31.10	34.30	337.00	10.50
45	1.00	12.00	5.50	5.04	14.20	41.50	82.30	28.20	34.20	183.00	10.40
46	1.00	12.00	4.80	5.39	16.30	47.70	88.50	30.20	34.20	334.00	10.50
47	1.00	12.00	7.00	5.24	15.00	44.00	84.00	28.60	34.10	318.00	10.30
48	1.00	12.00	5.10	5.23	14.50	42.50	81.30	27.70	34.10	371.00	10.80
49	1.00	12.00	7.30	5.34	15.00	44.00	82.40	28.10	34.10	278.00	10.60
50	1.00	11.00	6.30	4.69	13.90	40.80	87.00	29.60	34.10	232.00	11.00
51	1.00	11.00	3.60	4.90	14.50	42.50	86.70	29.60	34.10	251.00	10.10
52	1.00	12.00	6.50	5.11	15.00	44.10	86.30	29.40	34.00	317.00	10.70
53	1.00	12.00	6.80	5.33	15.40	45.30	85.00	28.90	34.00	320.00	11.00
54	1.00	12.00	8.90	4.99	14.80	43.60	87.40	29.70	33.90	377.00	10.50
55	1.00	11.00	6.80	5.60	15.30	45.10	80.50	27.30	33.90	231.00	10.60
56	1.00	12.00	5.00	5.05	14.80	43.80	86.70	29.30	33.80	226.00	10.60
57	1.00	12.00	5.60	5.58	15.30	45.30	81.20	27.40	33.80	199.00	10.50
58	1.00	12.00	6.90	4.78	14.20	42.00	87.90	29.70	33.80	260.00	10.70
59	1.00	11.00	7.30	4.61	13.90	41.10	89.20	30.20	33.80	435.00	10.90
60	1.00	11.00	5.10	5.57	16.10	47.70	85.60	28.90	33.80	340.00	10.10
61	1.00	11.00	6.20	4.86	14.10	41.70	85.80	29.00	33.80	237.00	11.10
62	1.00	12.00	5.50	4.62	12.60	37.40	81.00	27.30	33.70	322.00	10.30
63	1.00	12.00	10.50	5.27	14.20	42.10	79.90	26.90	33.70	354.00	10.80
64	1.00	12.00	8.30	5.18	14.20	42.10	81.30	27.40	33.70	365.00	10.20

#	Place	class	**WBC**	**RBC**	**Hgb**	**Hct**	**MCV**	**MCH**	**MCHC**	**PLT**	**RDW**
65	1.00	12.00	6.20	5.27	14.70	43.60	82.70	27.90	33.70	278.00	10.30
66	1.00	12.00	6.80	5.46	14.50	43.00	78.80	26.60	33.70	274.00	10.70
67	1.00	12.00	6.40	5.69	16.00	47.60	83.70	28.10	33.60	270.00	10.40
68	1.00	12.00	6.70	4.91	14.70	43.80	89.20	29.90	33.60	218.00	10.40
69	1.00	12.00	7.80	5.34	15.00	44.80	83.90	28.10	33.50	246.00	9.70
70	1.00	12.00	7.40	4.60	12.80	38.20	83.00	27.80	33.50	179.00	12.40
71	1.00	12.00	6.20	5.13	13.90	41.80	81.50	27.10	33.30	301.00	10.50
72	1.00	12.00	5.80	6.06	16.20	48.70	80.40	26.70	33.30	226.00	10.30
73	1.00	12.00	7.90	5.70	14.40	43.20	75.80	25.30	33.30	420.00	10.80
74	1.00	12.00	7.30	5.37	15.60	46.80	87.20	29.10	33.30	250.00	10.20
75	1.00	12.00	7.90	5.61	14.40	43.60	77.70	25.70	33.00	233.00	11.00
76	1.00	11.00	5.10	4.93	13.50	40.90	83.00	27.40	33.00	288.00	9.90
77	1.00	11.00	9.30	5.83	14.80	44.90	77.00	25.40	33.00	302.00	10.60
78	1.00	12.00	6.20	5.28	14.80	45.00	85.20	28.00	32.90	342.00	10.10
79	1.00	11.00	8.70	6.10	15.50	47.50	77.90	25.40	32.60	297.00	10.80
80	1.00	12.00	8.30	5.13	13.80	42.40	82.70	26.90	32.50	432.00	10.40
81	1.00	12.00	6.50	5.48	13.90	42.80	78.10	25.40	32.50	229.00	10.60
82	1.00	12.00	7.80	5.69	12.80	40.00	70.30	22.50	32.00	203.00	11.50
83	1.00	11.00	8.60	5.09	12.00	37.50	73.70	23.60	32.00	279.00	10.30
84	1.00	11.00	8.10	6.28	13.40	42.40	67.50	21.30	31.60	333.00	11.10
85	1.00	11.00	4.10	5.28	16.10	45.30	85.80	30.50	35.50	202.00	11.00
86	1.00	11.00	7.20	5.71	17.20	48.70	85.30	30.10	35.30	180.00	10.80
87	1.00	12.00	6.50	5.66	16.70	47.50	83.90	29.50	35.20	281.00	11.00
88	1.00	11.00	10.00	4.89	13.60	38.70	79.10	27.80	35.10	350.00	10.60
89	1.00	11.00	6.50	5.12	14.70	42.20	82.40	28.70	34.80	409.00	11.00
90	1.00	11.00	5.10	5.05	13.70	39.50	78.20	27.10	34.70	327.00	11.20
91	1.00	11.00	7.70	5.52	16.50	47.50	86.10	29.90	34.70	287.00	10.40
92	1.00	11.00	6.90	5.22	15.90	46.00	88.10	30.50	34.60	212.00	10.90
93	1.00	11.00	10.60	5.33	15.60	45.20	84.80	29.30	34.50	265.00	10.30
94	1.00	11.00	5.30	4.67	13.90	40.30	86.30	29.80	34.50	283.00	10.40
95	1.00	11.00	6.60	4.71	14.50	42.00	89.20	30.80	34.50	203.00	10.50
96	1.00	12.00	7.10	4.63	13.80	40.10	86.60	29.80	34.40	233.00	10.70
97	1.00	11.00	5.60	5.44	15.50	45.10	82.90	28.50	34.40	348.00	10.30

#	Place	class	**WBC**	**RBC**	**Hgb**	**Hct**	**MCV**	**MCH**	**MCHC**	**PLT**	**RDW**
98	1.00	11.00	5.90	5.79	17.50	50.80	87.70	30.20	34.40	261.00	10.50
99	1.00	11.00	9.70	5.24	15.60	45.40	86.60	29.80	34.40	342.00	10.70
100	1.00	11.00	6.70	4.86	14.70	42.80	88.10	30.20	34.30	256.00	10.40
101	1.00	11.00	10.80	5.25	15.50	45.20	86.10	29.50	34.30	362.00	10.40
102	1.00	11.00	8.00	5.31	15.30	44.70	84.20	28.80	34.20	300.00	10.40
103	1.00	11.00	7.00	5.51	15.30	44.70	81.10	27.80	34.20	299.00	10.70
104	1.00	11.00	9.60	5.46	15.60	45.60	83.50	28.60	34.20	224.00	10.80
105	1.00	11.00	5.30	5.13	15.30	44.70	87.10	29.80	34.20	210.00	10.50
106	1.00	11.00	4.40	5.14	15.20	44.50	86.60	29.60	34.20	326.00	10.00
107	1.00	11.00	12.40	5.63	16.60	48.50	86.10	29.50	34.20	346.00	10.60
108	1.00	11.00	7.00	4.81	14.30	41.90	87.10	29.70	34.10	164.00	10.70
109	1.00	11.00	5.60	5.00	15.00	44.00	88.00	30.00	34.10	295.00	10.40
110	1.00	11.00	6.50	4.52	14.00	41.10	90.90	31.00	34.10	302.00	10.10
111	1.00	12.00	6.50	4.51	12.80	37.60	83.40	28.40	34.00	368.00	10.70
112	1.00	11.00	7.10	5.04	14.20	41.80	82.90	28.20	34.00	368.00	10.70
113	1.00	11.00	6.70	5.78	16.70	49.30	85.30	28.90	33.90	380.00	10.30
114	1.00	11.00	9.40	5.36	14.70	43.30	80.80	27.40	33.90	353.00	12.20
115	1.00	12.00	8.60	5.18	15.40	45.60	88.00	29.70	33.80	307.00	9.80
116	1.00	12.00	8.00	4.50	14.00	41.40	92.00	31.10	33.80	314.00	9.80
117	1.00	11.00	4.30	5.43	15.50	45.80	84.30	28.50	33.80	217.00	10.80
118	1.00	11.00	9.20	4.88	14.00	41.40	84.80	28.70	33.80	466.00	10.20
119	1.00	11.00	5.40	4.83	13.80	40.80	84.50	28.60	33.80	255.00	10.20
120	1.00	11.00	8.80	5.27	13.60	40.40	76.70	25.80	33.70	385.00	10.80
121	1.00	11.00	10.50	5.42	14.30	42.40	78.20	26.40	33.70	442.00	11.80
122	1.00	12.00	4.50	4.92	14.00	41.70	84.80	28.50	33.60	309.00	10.30
123	1.00	11.00	6.40	5.18	14.30	42.60	82.20	27.60	33.60	235.00	10.20
124	1.00	11.00	6.50	4.89	14.40	42.80	87.50	29.40	33.60	237.00	10.50
125	1.00	11.00	9.10	4.97	14.70	43.80	88.10	29.60	33.60	465.00	10.70
126	1.00	11.00	6.10	4.57	14.00	41.80	91.50	30.60	33.50	196.00	9.70
127	1.00	11.00	6.20	5.14	13.00	38.80	75.50	25.30	33.50	408.00	11.30
128	1.00	11.00	6.60	5.49	14.40	43.00	78.30	26.20	33.50	301.00	10.60
129	1.00	11.00	8.30	5.85	16.00	47.90	81.90	27.40	33.40	296.00	9.90
130	1.00	11.00	8.30	5.40	13.40	40.30	74.60	24.80	33.30	316.00	11.50

#	Place	class	**WBC**	**RBC**	**Hgb**	**Hct**	**MCV**	**MCH**	**MCHC**	**PLT**	**RDW**
131	1.00	11.00	8.80	5.52	14.70	44.10	79.90	26.60	33.30	372.00	10.50
132	1.00	11.00	7.60	5.04	14.60	43.80	86.90	29.00	33.30	315.00	10.90
133	1.00	11.00	6.70	5.59	15.70	47.10	84.30	28.10	33.30	340.00	11.00
134	1.00	11.00	6.30	5.10	13.00	39.30	77.10	25.50	33.10	433.00	11.60
135	1.00	11.00	6.50	5.81	14.60	44.40	76.40	25.10	32.90	223.00	10.90
136	1.00	11.00	4.50	5.44	14.00	42.70	78.50	25.70	32.80	225.00	11.60
137	1.00	11.00	7.80	5.43	16.10	46.20	85.10	29.70	34.80	315.00	10.70
138	1.00	11.00	4.40	4.86	15.50	45.10	92.80	31.90	34.40	185.00	10.30
139	1.00	11.00	5.40	4.71	13.10	38.20	81.10	27.80	34.30	283.00	10.80
140	1.00	11.00	7.30	5.06	15.10	44.10	87.20	29.80	34.20	205.00	10.70
141	1.00	11.00	11.90	5.54	16.20	47.60	85.90	29.20	34.00	340.00	10.30
142	1.00	11.00	7.50	4.80	13.40	39.50	82.30	27.90	33.90	239.00	11.00
143	1.00	11.00	6.50	5.51	16.00	46.30	85.80	29.00	33.80	253.00	10.70
144	1.00	11.00	8.90	4.77	13.60	40.20	84.30	28.50	33.80	398.00	10.40
145	1.00	11.00	8.10	4.97	14.40	42.80	86.10	29.00	33.60	321.00	11.60
146	1.00	11.00	7.40	5.33	15.20	45.20	84.80	28.50	33.60	257.00	10.80
147	2.00	12.00	8.46	5.69	16.60	47.90	84.20	29.20	34.70	392.00	10.10
148	2.00	12.00	7.50	5.92	16.90	48.80	82.40	28.50	34.60	229.00	10.90
149	2.00	12.00	5.60	4.86	15.30	43.40	89.30	31.50	35.30	279.00	10.50
150	2.00	12.00	12.50	5.20	16.30	46.40	89.20	31.30	35.10	345.00	9.70
151	2.00	12.00	7.60	6.17	18.40	52.60	85.30	29.80	35.00	236.00	10.60
152	2.00	12.00	8.00	5.36	16.00	45.70	85.30	29.90	35.00	128.00	10.30
153	2.00	12.00	8.70	5.73	16.40	46.90	81.80	28.60	35.00	168.00	11.10
154	2.00	12.00	5.50	5.55	16.10	46.30	83.40	29.00	34.80	317.00	10.90
155	2.00	12.00	7.80	5.47	15.40	44.40	81.20	28.20	34.70	272.00	10.40
156	2.00	12.00	8.00	6.09	18.10	52.10	85.60	29.70	34.70	263.00	10.80
157	2.00	12.00	8.40	5.43	15.90	45.90	84.50	29.30	34.60	247.00	11.80
158	2.00	12.00	6.20	5.12	14.90	43.10	84.20	29.10	34.60	232.00	10.30
159	2.00	12.00	6.40	5.40	15.70	45.50	84.30	29.10	34.50	339.00	10.50
160	2.00	12.00	7.60	5.34	16.50	47.80	89.50	30.90	34.50	301.00	10.60
161	2.00	12.00	5.50	4.82	14.90	43.20	89.60	30.90	34.50	254.00	10.30
162	2.00	12.00	6.30	5.36	15.40	44.70	83.40	28.70	34.50	247.00	10.90
163	2.00	12.00	7.50	5.64	15.90	46.10	81.70	28.20	34.50	191.00	10.60

#	Place	class	**WBC**	**RBC**	**Hgb**	**Hct**	**MCV**	**MCH**	**MCHC**	**PLT**	**RDW**
164	2.00	12.00	7.80	5.57	15.80	45.80	82.20	28.40	34.50	249.00	10.80
165	2.00	12.00	6.90	5.17	15.10	43.70	84.70	29.20	34.50	294.00	10.20
166	2.00	12.00	3.80	5.32	15.40	44.60	83.80	28.90	34.50	268.00	11.20
167	2.00	12.00	5.80	5.11	15.80	45.80	89.60	30.90	34.50	301.00	10.30
168	2.00	11.00	5.90	4.71	14.10	41.00	87.00	29.90	34.40	218.00	10.30
169	2.00	12.00	7.10	5.40	16.50	48.10	89.10	30.60	34.30	234.00	10.40
170	2.00	12.00	7.50	6.13	17.10	49.80	81.20	27.90	34.30	229.00	10.70
171	2.00	12.00	5.00	5.04	15.80	46.10	91.50	31.30	34.30	222.00	10.30
172	2.00	12.00	6.00	5.07	15.70	45.80	90.30	31.00	34.30	249.00	10.20
173	2.00	11.00	7.80	5.03	14.60	42.60	84.70	29.00	34.30	367.00	10.70
174	2.00	12.00	9.10	5.59	15.90	46.50	83.20	28.40	34.20	231.00	10.20
175	2.00	12.00	10.20	5.32	15.30	44.80	84.20	28.80	34.20	311.00	10.00
176	2.00	11.00	8.30	4.56	13.90	40.70	89.30	30.50	34.20	220.00	10.60
177	2.00	12.00	7.10	6.09	17.70	51.90	85.20	29.10	34.10	213.00	10.60
178	2.00	12.00	9.80	5.55	15.50	45.50	82.00	27.90	34.10	337.00	10.80
179	2.00	12.00	8.20	5.02	14.80	43.40	86.50	29.50	34.10	321.00	10.20
180	2.00	12.00	9.00	5.48	16.20	47.50	86.70	29.60	34.10	318.00	10.00
181	2.00	12.00	10.90	5.27	15.40	45.30	86.00	29.20	34.00	375.00	10.50
182	2.00	12.00	8.40	5.39	15.30	45.00	83.50	28.40	34.00	222.00	10.50
183	2.00	12.00	6.80	5.36	15.20	44.70	83.40	28.40	34.00	270.00	10.80
184	2.00	12.00	4.40	5.37	14.80	43.50	81.00	27.60	34.00	316.00	11.20
185	2.00	12.00	5.60	5.33	14.90	44.00	82.60	28.00	33.90	339.00	10.50
186	2.00	12.00	11.30	5.55	15.00	44.20	79.60	27.00	33.90	232.00	11.90
187	2.00	12.00	5.00	4.40	12.90	38.10	86.60	29.30	33.90	273.00	11.20
188	2.00	12.00	3.40	4.73	13.90	41.10	86.90	29.40	33.80	249.00	10.00
189	2.00	12.00	8.10	5.27	16.30	48.30	91.70	30.90	33.70	215.00	10.20
190	2.00	12.00	6.00	5.46	14.50	43.00	78.80	26.60	33.70	265.00	10.00
191	2.00	12.00	7.40	6.18	15.90	47.20	76.40	25.70	33.70	271.00	11.00
192	2.00	12.00	6.30	5.78	14.40	42.70	73.90	24.90	33.70	223.00	11.20
193	2.00	11.00	9.90	5.45	15.60	46.40	85.10	28.60	33.60	264.00	11.10
194	2.00	12.00	10.10	5.36	16.00	47.70	89.00	29.90	33.50	308.00	9.90
195	2.00	12.00	7.40	5.62	15.20	45.50	81.00	27.00	33.40	268.00	10.90
196	2.00	12.00	7.60	5.58	15.80	47.40	84.90	28.30	33.30	274.00	10.30

#	Place	class	**WBC**	**RBC**	**Hgb**	**Hct**	**MCV**	**MCH**	**MCHC**	**PLT**	**RDW**
197	2.00	12.00	4.20	5.03	13.00	39.10	77.70	25.80	33.20	252.00	11.20
198	2.00	12.00	10.50	6.28	15.90	48.10	76.60	25.30	33.10	312.00	11.10
199	2.00	11.00	6.70	5.21	15.70	45.10	86.60	30.10	34.80	300.00	10.30
200	2.00	11.00	7.20	5.06	16.00	45.00	88.90	31.60	35.60	256.00	10.60
201	2.00	11.00	7.40	4.86	14.70	41.50	85.40	30.20	35.40	286.00	10.40
202	2.00	11.00	7.50	4.97	15.00	42.40	85.30	30.20	35.40	244.00	10.60
203	2.00	11.00	7.60	5.30	16.60	46.90	88.50	31.30	35.40	240.00	10.30
204	2.00	11.00	6.80	5.35	15.80	44.90	83.90	29.50	35.20	210.00	11.50
205	2.00	12.00	5.50	4.48	14.40	41.20	92.00	32.10	35.00	236.00	9.90
206	2.00	11.00	6.40	5.25	15.90	45.40	86.50	30.30	35.00	237.00	10.50
207	2.00	11.00	7.10	5.88	16.70	47.90	81.50	28.40	34.90	300.00	10.50
208	2.00	11.00	5.40	5.64	16.30	46.70	82.80	28.90	34.90	246.00	10.80
209	2.00	12.00	7.20	5.68	16.90	48.60	85.60	29.80	34.80	197.00	10.20
210	2.00	12.00	7.40	5.65	16.90	48.70	86.20	29.90	34.70	240.00	10.40
211	2.00	12.00	8.90	5.00	15.70	45.20	90.40	31.40	34.70	290.00	10.50
212	2.00	11.00	6.20	4.82	14.40	41.50	86.10	29.90	34.70	214.00	10.90
213	2.00	11.00	6.90	5.40	15.30	44.10	81.70	28.30	34.70	214.00	10.90
214	2.00	11.00	8.30	4.99	15.40	44.40	89.00	30.90	34.70	282.00	10.10
215	2.00	11.00	6.30	5.41	15.60	45.10	83.40	28.80	34.60	197.00	10.80
216	2.00	11.00	10.20	4.93	14.20	41.00	83.20	28.80	34.60	250.00	10.50
217	2.00	11.00	11.50	5.23	14.70	42.50	81.30	28.10	34.60	288.00	10.50
218	2.00	11.00	5.20	5.63	16.00	46.20	82.10	28.40	34.60	258.00	10.70
219	2.00	11.00	8.50	5.00	15.10	43.70	87.40	30.20	34.60	365.00	10.70
220	2.00	11.00	7.10	5.32	15.70	45.40	85.30	29.50	34.60	238.00	10.50
221	2.00	11.00	5.10	4.71	14.30	41.30	87.76	30.40	34.60	155.00	10.80
222	2.00	11.00	7.80	5.07	15.20	44.00	86.80	30.00	34.50	245.00	11.10
223	2.00	11.00	5.40	4.73	14.30	41.00	87.70	30.20	34.50	165.00	10.70
224	2.00	11.00	7.20	5.18	15.30	44.40	85.70	29.50	34.50	252.00	10.30
225	2.00	11.00	7.70	5.65	16.20	46.90	83.00	28.70	34.50	254.00	11.00
226	2.00	11.00	6.20	5.29	15.40	44.60	84.30	29.10	34.50	308.00	11.00
227	2.00	12.00	5.80	5.43	15.60	46.20	83.70	28.20	34.40	188.00	10.40
228	2.00	11.00	8.90	5.98	17.10	49.70	83.10	28.60	34.40	225.00	10.60
229	2.00	11.00	7.10	5.49	16.40	47.70	86.90	29.90	34.40	263.00	10.60

#	Place	class	**WBC**	**RBC**	**Hgb**	**Hct**	**MCV**	**MCH**	**MCHC**	**PLT**	**RDW**
230	2.00	11.00	7.00	5.01	14.40	41.80	83.40	28.70	34.40	276.00	11.00
231	2.00	11.00	4.90	5.34	15.70	45.60	85.40	29.40	34.40	232.00	10.30
232	2.00	11.00	6.00	5.20	15.30	44.50	85.60	29.40	34.40	261.00	10.40
233	2.00	11.00	7.00	5.54	16.50	48.10	86.80	29.80	34.30	264.00	10.20
234	2.00	11.00	6.00	5.58	15.90	46.30	83.00	28.50	34.30	189.00	11.00
235	2.00	12.00	6.00	5.61	16.00	46.80	83.40	28.50	34.20	251.00	10.70
236	2.00	11.00	5.20	5.28	14.90	43.60	82.60	28.20	34.20	309.00	11.50
237	2.00	11.00	9.10	5.64	15.20	44.50	78.90	27.00	34.20	288.00	10.20
238	2.00	11.00	6.70	5.30	15.10	44.10	83.20	28.50	34.20	232.00	10.10
239	2.00	11.00	7.20	5.30	14.20	41.50	78.30	26.80	34.20	268.00	10.60
240	2.00	12.00	5.60	5.47	15.60	45.80	83.70	28.50	34.10	178.00	10.60
241	2.00	12.00	6.70	5.73	16.00	47.00	82.00	27.90	34.00	238.00	10.90
242	2.00	12.00	4.60	5.43	14.60	43.00	79.20	26.90	34.00	196.00	10.70
243	2.00	12.00	5.50	5.61	16.00	47.10	84.00	28.50	34.00	325.00	9.90
244	2.00	11.00	7.30	5.38	14.80	43.50	80.90	27.50	34.00	266.00	10.70
245	2.00	11.00	7.20	4.94	14.70	43.20	87.40	29.80	34.00	285.00	10.40
246	2.00	11.00	7.20	5.35	16.10	47.30	88.40	30.10	34.00	229.00	10.70
247	2.00	11.00	6.30	5.04	14.80	43.50	86.30	29.40	34.00	295.00	10.70
248	2.00	11.00	8.70	4.89	14.30	42.10	86.10	29.20	34.00	336.00	10.50
249	2.00	11.00	5.90	5.53	16.20	47.60	86.10	29.30	34.00	133.00	11.00
250	2.00	11.00	7.60	5.22	14.70	43.20	82.80	28.20	34.00	209.00	11.00
251	2.00	11.00	7.20	4.92	14.40	42.40	86.20	29.30	34.00	310.00	10.50
252	2.00	12.00	6.00	5.21	15.30	45.10	86.60	29.40	33.90	283.00	10.40
253	2.00	12.00	8.50	4.67	13.70	40.40	86.50	29.30	33.90	301.00	10.40
254	2.00	11.00	9.30	5.17	14.80	43.60	84.30	28.60	33.90	272.00	10.60
255	2.00	11.00	5.70	5.35	15.70	46.30	86.50	29.30	33.90	232.00	10.20
256	2.00	11.00	7.00	5.08	14.80	43.70	86.00	29.10	33.90	270.00	10.70
257	2.00	11.00	7.40	4.84	14.00	41.30	85.30	28.90	33.90	304.00	11.20
258	2.00	11.00	6.70	4.86	14.50	42.80	88.10	29.80	33.90	304.00	10.80
259	2.00	11.00	5.80	5.47	16.10	47.50	86.80	29.40	33.90	295.00	10.20
260	2.00	11.00	4.40	5.39	14.90	44.00	81.60	27.60	33.90	174.00	10.50
261	2.00	11.00	5.60	5.17	14.40	42.60	82.40	27.90	33.80	355.00	10.80
262	2.00	11.00	5.90	5.29	15.50	45.80	86.60	29.30	33.80	278.00	10.80

#	Place	class	**WBC**	**RBC**	**Hgb**	**Hct**	**MCV**	**MCH**	**MCHC**	**PLT**	**RDW**
263	2.00	11.00	7.40	5.73	15.30	45.30	79.10	26.70	33.80	282.00	10.50
264	2.00	11.00	6.90	4.84	13.40	39.60	81.80	27.70	33.80	253.00	10.80
265	2.00	11.00	9.20	5.59	15.60	46.20	82.60	27.90	33.80	142.00	11.10
266	2.00	11.00	6.40	4.93	14.00	41.40	84.00	28.40	33.80	368.00	10.40
267	2.00	11.00	6.10	5.25	14.80	43.80	83.40	28.20	33.80	181.00	11.00
268	2.00	11.00	7.10	5.05	14.30	42.30	83.80	28.30	33.80	277.00	10.80
269	2.00	11.00	5.70	4.73	13.30	39.40	83.30	28.10	33.80	315.00	10.60
270	2.00	11.00	5.40	5.00	13.90	41.20	82.40	27.80	33.70	175.00	11.40
271	2.00	11.00	6.00	5.26	14.40	42.80	81.40	27.40	33.60	164.00	10.50
272	2.00	11.00	9.70	6.11	15.80	47.20	77.30	25.90	33.50	444.00	10.80
273	2.00	11.00	6.20	5.35	15.20	45.40	84.90	28.40	33.50	282.00	10.50
274	2.00	11.00	9.50	5.24	14.60	43.60	83.20	27.90	33.50	269.00	11.30
275	2.00	11.00	6.40	5.72	15.20	45.40	79.40	26.60	33.50	289.00	10.80
276	2.00	12.00	6.80	6.00	15.80	47.30	78.80	26.30	33.40	318.00	10.20
277	2.00	11.00	10.60	5.22	14.70	44.00	84.30	28.20	33.40	204.00	11.30
278	2.00	11.00	4.60	5.73	12.70	38.20	66.70	22.20	33.20	344.00	12.50
279	2.00	11.00	6.10	4.98	13.80	41.90	84.10	27.70	32.90	227.00	10.90
280	2.00	11.00	6.00	5.71	12.80	39.10	68.50	22.40	32.70	201.00	11.70
281	2.00	11.00	6.60	4.92	13.30	40.80	82.90	27.00	32.60	195.00	10.20
282	2.00	11.00	4.90	5.57	13.60	41.80	75.00	24.40	32.50	214.00	10.80
283	2.00	11.00	7.60	6.19	14.30	44.60	72.10	23.10	32.10	211.00	11.70
284	2.00	11.00	7.50	5.48	15.30	43.70	79.70	27.90	35.00	311.00	10.70
285	2.00	11.00	6.70	5.52	16.00	45.90	83.20	29.00	34.90	299.00	10.70
286	2.00	11.00	6.40	5.65	16.30	46.80	82.80	28.80	34.80	243.00	10.70
287	2.00	12.00	7.30	4.88	15.10	43.70	89.50	30.90	34.60	255.00	10.40
288	2.00	11.00	6.70	5.18	15.50	44.80	86.50	29.90	34.60	251.00	10.30
289	2.00	11.00	4.10	5.55	15.30	44.50	80.20	27.60	34.40	232.00	10.60
290	2.00	11.00	5.00	5.19	15.30	44.60	85.90	29.50	34.30	216.00	9.90
291	2.00	11.00	7.20	4.99	14.60	42.60	85.40	29.30	34.30	388.00	10.60
292	2.00	11.00	5.20	5.01	14.00	40.90	81.60	27.90	34.20	177.00	10.70
293	2.00	11.00	5.80	4.83	14.80	43.40	89.90	30.60	34.10	228.00	10.70
294	2.00	11.00	7.00	4.98	14.30	42.10	84.50	28.70	34.00	291.00	10.90
295	2.00	11.00	6.20	5.23	14.20	41.90	80.10	27.20	33.90	363.00	10.10

#	Place	class	**WBC**	**RBC**	**Hgb**	**Hct**	**MCV**	**MCH**	**MCHC**	**PLT**	**RDW**
296	2.00	11.00	4.00	5.88	16.20	48.40	82.30	27.60	33.50	240.00	10.80
297	2.00	11.00	5.20	5.34	14.60	43.80	82.00	27.30	33.30	271.00	10.60

Annex II: Analysis of the questionnaire

Information collected by the questionnaire		Place					
		Jericho		Ramallah		Total	
		N	%	N	%	N	%
Class	11	81	55.5%	89	58.9%	170	57.2%
	12	65	44.5%	62	41.1%	127	42.8%
	Total	146	100.0%	151	100.0%	297	100.0%
Residence place	City	102	69.9%	102	67.5%	204	68.7%
	Village	8	5.5%	14	9.3%	22	7.4%
	Camp	36	24.7%	35	23.2%	71	23.9%
Residence time 6 months in the place	Yes	146	100.0%	149	98.7%	295	99.3%
	No	0	0.0%	2	1.3%	2	0.7%
Smoking	Yes	44	30.1%	54	35.8%	98	33.0%
	No	102	69.9%	97	64.2%	199	67.0%
Smoking quantity (> 20 cigarette/day)	Yes	11	25.0%	16	29.6%	27	27.6%
	No	33	75.0%	38	70.4%	71	72.4%
Meat eating	Meat	141	96.6%	136	90.1%	277	93.3%
	Vegetarian	5	3.4%	15	9.9%	20	6.7%
Obesity	Under weight	13	8.9%	10	6.6%	23	7.7%
	Normal weight	108	74.0%	100	66.2%	208	70.0%
	Over weight	21	14.4%	33	21.9%	54	18.2%
	Obese	4	2.7%	8	5.3%	12	4.0%
Eating breakfast	Yes	93	63.7%	81	53.6%	174	58.6%
	No	53	36.3%	70	46.4%	123	41.4%
Drinking tea with meals	Yes	88	60.3%	101	66.9%	189	63.6%
	No	58	39.7%	50	33.1%	108	36.4%
Tea quantity during meals (Cups / meal)	One	44	50.0%	54	52.9%	98	51.6%
	Two	34	38.6%	38	37.3%	72	37.9%
	three	10	11.4%	10	9.8%	20	10.5%
Meals number/day	One	3	2.1%	5	3.3%	8	2.7%
	Two	50	34.2%	58	38.4%	108	36.4%
	Three	93	63.7%	88	58.3%	181	60.9%
Sports	Yes	43	29.5%	56	37.1%	99	33.3%
	No	103	70.5%	95	62.9%	198	66.7%

Information collected by the questionnaire		Place					
		Jericho		Ramallah		Total	
		N	%	N	%	N	%
Have chronic disease	Yes	1	0.7%	6	4.0%	7	2.4%
	No	144	99.3%	143	96.0%	287	97.6%
Life-long drugs	Yes	2	1.4%	2	1.3%	4	1.3%
	No	144	98.6%	149	98.7%	293	98.7%
Are you Thalassemia carrier?	Yes	0	0.0%	1	0.7%	1	0.3%
	No	75	51.4%	60	39.7%	135	45.5%
	Don’t know	71	48.6%	90	59.6%	161	54.2%
previous blood transfusion	Yes	2	1.4%	15	9.9%	17	5.7%
	No	144	98.6%	136	90.1%	280	94.3%
Recent blood transfusion	Yes	0	0.0%	4	28.6%	4	25.0%
	No	2	100.0%	10	71.4%	12	75.0%
Family persons number	< 5	17	11.6%	22	14.6%	39	13.1%
	>/= 5	129	88.4%	129	85.4%	258	86.9%
Father education level	No secondary school education	54	37.0%	53	35.1%	107	36.0%
	Secondary school education	44	30.1%	41	27.2%	85	28.6%
	Diploma (2 years)	2	1.4%	16	10.6%	18	6.1%
	BA	40	27.4%	35	23.2%	75	25.3%
	MA	6	4.1%	5	3.3%	11	3.7%
	Ph.D.	0	0.0%	1	0.7%	1	0.3%
Mother education level	No secondary	56	38.4%	51	33.8%	107	36.0%
	Secondary	54	37.0%	52	34.4%	106	35.7%
	Diploma	9	6.2%	19	12.6%	28	9.4%
	BA	19	13.0%	20	13.2%	39	13.1%
	MA	7	4.8%	9	6.0%	16	5.4%
	Ph.D.	1	0.7%	0	0.0%	1	0.3%
Family income/month	< 2500 nis	47	32.2%	34	22.5%	81	27.3%
	2500-4500 nis	73	50.0%	75	49.7%	148	49.8%
	> 4500 nis	26	17.8%	42	27.8%	68	22.9%

Annex III: Questionnaire in Arabic

عزيزي الطالب:

- ضمن برنامج ماجستير العلوم الطبيه المخبريه/تخصص علم الدم في جامعة القدس يسرنا أن ندعوكم إلى المشاركة في البحث المتعلّق في (مقارنة الفرق في فحوصات الدم بين الأشخاص الذين يعيشون في مناطق مرتفعة ومناطق منخفضة عن مستوى سطح البحر)، حيث سيتم المقارنه بين الطلاب الذكور من الصّفين (11+12) في كل من مدينتي أريحا ورام الله.

إذا كنت ترغب في المشاركة في البحث المذكور نرجو منك التفضّل بالإجابة عن أسئلة الإستبيان التالي والتكرّم بالسماح لنا بسحب عينة دم صغيره (3 ملليلتر) لإجراء الفحوصات عليها.

- لك كامل الحريّة في المشاركة في هذا البحث ، ولك الحق في أخذ الوقت الكافي للتفكير في المشاركة أو عدم المشاركة وسؤال الباحث عمّا تراه مناسباً. كما يمكنك الإستفسار عن أي جزء يتعلّق بالبحث الآن أو فيما بعد، وإذا كان هناك كلمات أو أجزاء غير مفهومه في الإستبيان فبإمكانك سؤال الباحث وستحصل على الإجابة الكافيه.
- يضمن البحث سرّية المعلومات المتعلقة بالمشارك.
- إعطاء الإسم هو إختياري (في حال كنت ترغب في الحصول على نتيجة فحص الدم الخاص بك).

- الباحث: جبر حج علي- 0598996085 jabrcomm@yahoo.com

هذا الجزء خاص بالباحث:

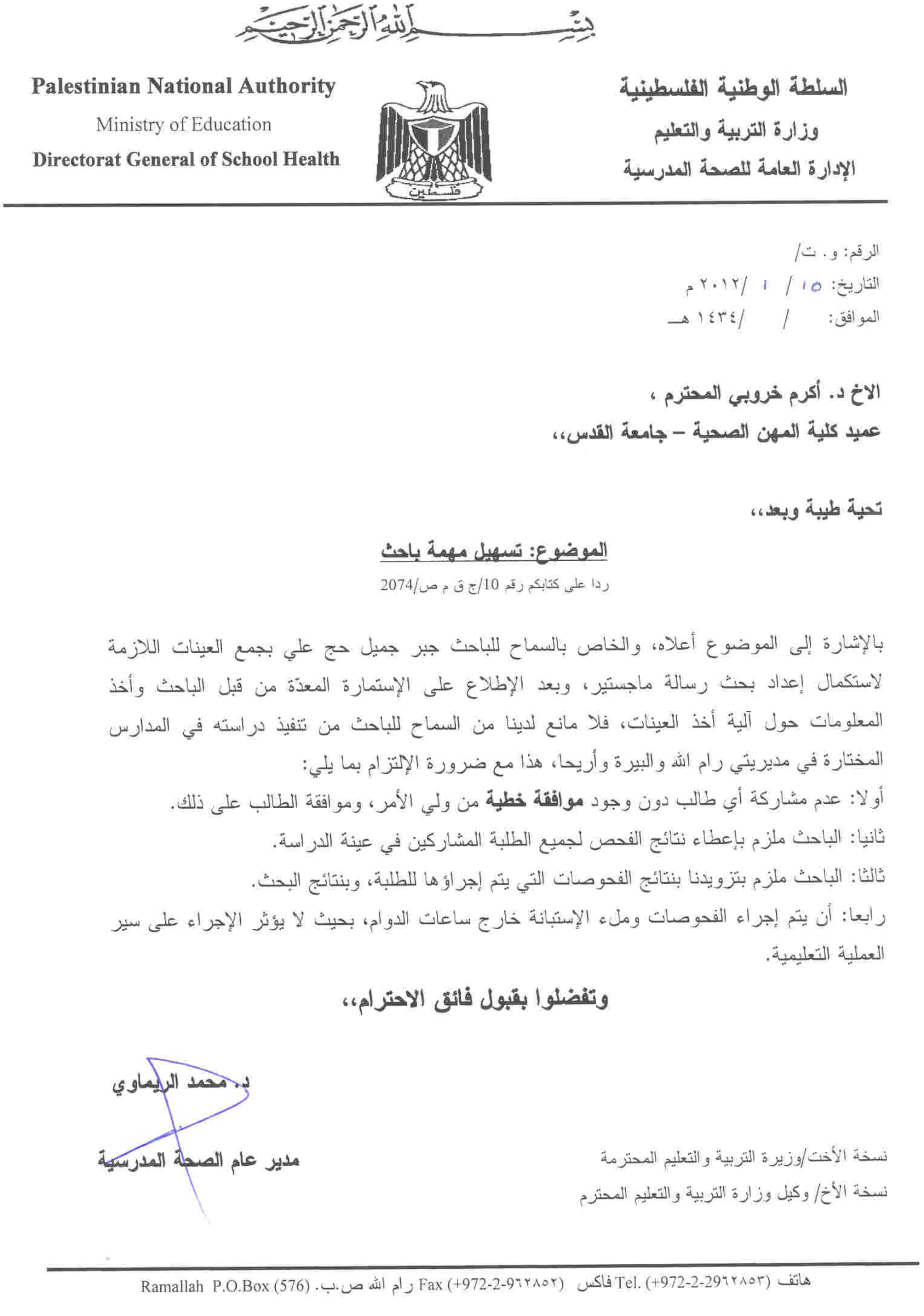
الرقم المتسلسل:	
الإسم	
مديرية التربية	
المدرسه	
تاريخ الولاده	
تاريخ سحب عينة الدم	
ساعة سحب عينة الدم	
درجة حرارة الجو عند سحب عينة الدم	

يوضع دائرة على رقم الكلمة التي تتوافق مع إجابة السؤال:

هل تقيم في:	**1- مدينه -2 قريه 3- مخيّم**
هل تقيم في المكان منذ ستة شهور فأكثر؟	**1- نعم 2- لا**
هل أنت مدخّن؟	**1- نعم 2- لا**
إذا كنت مدخّن، هل تدخّن علبة سجائر فأكثر يوميّاً؟	**1- نعم 2- لا**
هل تأكل اللحوم أم أنت نباتي؟	**1- تأكل اللحوم. 2- نباتي**
هل تتناول طعام الفطور عادة؟	**1- نعم 2- لا**
هل تشرب الشاي مع وجبات الطعام أو بعدها مباشرة عادة؟	**1- نعم 2- لا**
إذا كنت تشرب الشاي مع الوجبات أو بعدها مباشرة كم كوب تشرب؟	**1- واحد 2- إثنان 3- ثلاثه فأكثر.**
ما هو عدد الوجبات التي تتناولها يوميّاً ؟	**1- واحده 2- إثنتان 3- ثلاثه أو أكثر.**
هل تمارس الرياضه باستمرار؟	**1- نعم 2- لا**
إذا كنت تمارس الرياضه، أذكر نوع الرياضه التي تمارسها غالبا؟	
هل تعاني من أية أمراض مزمنه؟	**2- نعم 2- لا**
إذا كان الجواب نعم، أذكر المرض؟	
هل تتعاطى أية أدويه بشكل دائم؟	**1- نعم 2- لا**
إذا كان الجواب نعم، أذكر الأدويه؟	
هل أنت حامل لصفة مرض الثلاسيميا؟	**1- نعم 2- لا 3- لا أعلم.**
هل تلقيت نقل دم في السابق؟	**1- نعم 2- لا**
إذا كنت تلقيت نقل دم سابقا هل كان ذلك خلالالثلاثةشهورالماضيه؟	**1- نعم 2- لا**
ما هو عدد أفراد الأسره التي تعيش معهم؟	**1- أقل من خمسه 2- خمسه فأكثر / العدد:**

ما هي الدرجه العلميه للأب؟	1- غير حاصل على الثانويه 4- بكالوريوس 2- الثانويه العامه. 5- ماجستير 3- دبلوم 6- دكتوراه.
ما هي الدرجه العلميه للأم؟	1- غير حاصله على الثانويه 4- بكالوريوس 2- الثانويه العامه. 5- ماجستير 3- دبلوم 6- دكتوراه.
هل دخل الأسره الشهري بالشيكل هو:	1- أقل من 2500 2- (2500- 4500) 3- أكثر من 4500
قياسات الطول والوزن	الطول"سم" : ( )
	الوزن "كغم" : ( )

Annex IV: Ministry of education permission



بسم الله الرحمن الرحيم

Palestinian National Authority
Ministry of Education
Directorat General of School Health

السلطة الوطنية الفلسطينية
وزارة التربية والتعليم
الإدارة العامة للصحة المدرسية

الرقم: و. ت/
التاريخ: ١٥ / ١ /٢٠١٢ م
الموافق: / /١٤٣٤ هـ

الاخ د. أكرم خروبي المحترم ،
عميد كلية المهن الصحية – جامعة القدس،،

تحية طيبة وبعد،،

الموضوع: تسهيل مهمة باحث

ردا على كتابكم رقم 10/ج ق م ص/2074

بالإشارة إلى الموضوع أعلاه، والخاص بالسماح للباحث جبر جميل حج علي بجمع العينات اللازمة لاستكمال إعداد بحث رسالة ماجستير، وبعد الإطلاع على الإستمارة المعدّة من قبل الباحث وأخذ المعلومات حول آلية أخذ العينات، فلا مانع لدينا من السماح للباحث من تنفيذ دراسته في المدارس المختارة في مديريتي رام الله والبيرة وأريحا، هذا مع ضرورة الإلتزام بما يلي:
أولا: عدم مشاركة أي طالب دون وجود **موافقة خطية** من ولي الأمر، وموافقة الطالب على ذلك.
ثانيا: الباحث ملزم بإعطاء نتائج الفحص لجميع الطلبة المشاركين في عينة الدراسة.
ثالثا: الباحث ملزم بتزويدنا بنتائج الفحوصات التي يتم إجراؤها للطلبة، وبنتائج البحث.
رابعا: أن يتم إجراء الفحوصات وملء الإستبانة خارج ساعات الدوام، بحيث لا يؤثر الإجراء على سير العملية التعليمية.

وتفضلوا بقبول فائق الاحترام،،

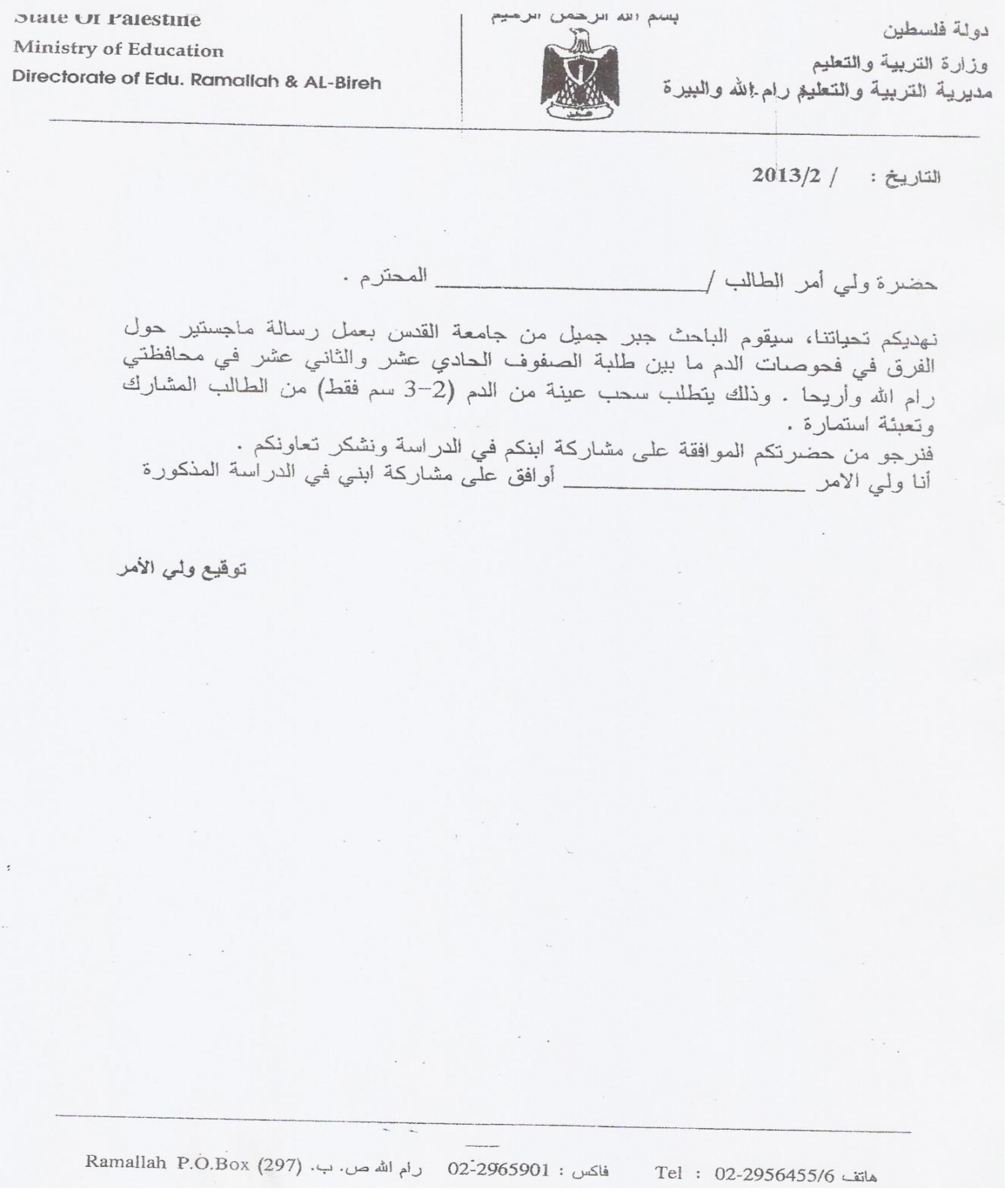
د. محمد الريماوي

مدير عام الصحة المدرسية

نسخة الأخت/وزيرة التربية والتعليم المحترمة
نسخة الأخ/ وكيل وزارة التربية والتعليم المحترم

Ramallah P.O.Box (576) .رام الله ص.ب Fax (+972-2-9٦٢٨٥٢) فاكس Tel. (+972-2-29٦٢٨٥٣) هاتف

Annex V: Students guardians consent form



State Of Palestine
Ministry of Education
Directorate of Edu. Ramallah & AL-Bireh

بسم الله الرحمن الرحيم

دولة فلسطين
وزارة التربية والتعليم
مديرية التربية والتعليم رام الله والبيرة

التاريخ :   / 2013/2

حضرة ولي أمر الطالب /__________________ المحترم .

نهديكم تحياتنا، سيقوم الباحث جبر جميل من جامعة القدس بعمل رسالة ماجستير حول الفرق في فحوصات الدم ما بين طلبة الصفوف الحادي عشر والثاني عشر في محافظتي رام الله وأريحا . وذلك يتطلب سحب عينة من الدم (2–3 سم فقط) من الطالب المشارك وتعبئة استمارة .

فنرجو من حضرتكم الموافقة على مشاركة ابنكم في الدراسة ونشكر تعاونكم .

أنا ولي الامر ________________ أوافق على مشاركة ابني في الدراسة المذكورة

توقيع ولي الأمر

Ramallah P.O.Box (297) رام الله ص. ب. 02-2965901 : فاكس Tel : 02-2956455/6 هاتف

تأثير الإقامة تحت مستوى سطح البحر على فحص تعداد الدم الكامل (CBC)

الدكتور المشرف: الأستاذ خالد اليونس

الباحث: جبر جميل إبراهيم حج علي

الملخص

على المرتفعات العالية ينخفض الضغط الجوي فينخفض توفّر الأكسجين في الهواء مؤديا إلى حالة من نقص الأكسجة في الشرايين والأنسجة الحيوية، فيزداد تبعاً لذلك إفراز هرمون " الإريثروبويتين" من الكِلية، ويقوم هذا الهرمون بتحفيز إنتاج خلايا الدم الحمراء و تصنيع خضاب الدم (الهيموجلوبين)، وتحصل هذه العمليات بآليات حيوية معقّدة تهدف للتأقلم مع الوضع الجديد وتعويض النقص الحاصل في نقل الأكسجين إلى أنسجة الجسم. هناك العديد من الدّراسات التي تصف عمليات التأقلم والتكيّف على المرتفعات العالية وتأثير ذلك على قيم فحص تعداد الدم الكامل CBC، معظم هذه الدراسات أثبتت أن هناك زيادة في تركيز خضاب الدم " الهيموجلوبين" و إفراز هرمون الـ " إريثروبيوتين" ، ولكن ما زال هناك نقص واضح في المعلومات المتوفرة عن تأثير العيش تحت مستوى سطح البحر على نتائج فحص تعداد الدم الكامل CBC.

هدفت هذه الدّراسة من جهة إلى تقييم نتائج فحص تعداد الدم الكامل (CBC) لدى أولئك الذين يعيشون تحت مستوى سطح البحر بحوالي 300 متر ومقارنة نتائجهم مع أولئك الذين يقطنون على إرتفاع حوالي 900 متر عن مستوى سطح البحر، وذلك للمرّة الأولى في فلسطين، كماهدفت هذه الدّراسة من جهة ثانية إلى تقييم إمكانيّة الإستمرار في الإعتماد على القيم الطبيعية لفحص الدم CBC والمتوفّرة في الأبحاث والدراسات العالمية في الحكم على نتائج هذا الفحص للشعب

الفلسطيني فيما إذا كان طبيعياً أم غير طبيعي، و قد قمنا من أجل ذلك بمقارنة معدّلات نتائج الفحص التي حصلنا عليها في دراستنا مع المعدّلات الموجودة في المراجع العالمية.

تم إجراء هذه الدراسة خلال شهر شباط من سنة 2013 ، حيث قمنا بإختيار عينة عشوائية من طلاب الصّفين الحادي عشر والثاني عشر الذكور من أربعة مدارس، إثنتين في مدينة أريحا الواقعة تحت مستوى سطح البحر وإثنتين في مدينة رام الله، وتراوحت بذلك أعمار الطلاب المدروسين ما بين 16 – 19 سنة، وقد تم توزيع إستبيان على 400 طالب في كلا المدرستين تم إختيار 320 منهم بعد موافقة أولياء أمورهم، وبعد أخذ عينات الدم وفحصها تم إستبعاد 23 نتيجة ليتم إجراء الدراسة على 297 نتيجة طالب منهم 146 في أريحا و 151 في رام الله باستخدام برنامج SPSS وفحص t– test لحساب الفرق بين معدّلين.

وقد أشارت النتائج إلى وجود فروق ذات دلالة أحصائية بين الطلاب في أريحا و رام الله في تعداد خلايا الدم الحمراء والهيموجلوبين و مكداس الدم (الهيماتوكريت) بوجود زيادة لصالح أولئك الذين يقيمون على إرتفاع 900 متر عن سطح البحر ، بينما كان هناك زيادة ذات دلالة إحصائية في تعداد الصفيحات الدمويّة لدى أولئك القاطنين على مستوى 300 متر تحت مستوى سطح البحر.

ومن جهة ثانية أظهرت النتائج وجود فروق ذات دلالة إحصائية بين القيم الطبيعية المستخدمة لفحصCBC والموجودة في المراجع العالميّة وبين القيم الطبيعية المستقاة من عينة الدراسة التي قمنا بها وذلك في كل من رام الله وأريحا، الأمر الذي يبرر من وجهة نظرنا الحاجة للعمل على

تأسيس قيم طبيعية خاصة بالشعب الفلسطيني من هذه الفئة العمريّة خاصّة و لجميع البالغين من الذكور بشكل عام.

الخلاصة: لقد وجدنا أنّ هناك فروقاً ذات دلالة إحصائيّة في قيم كل من خضاب الدم "الهيموجلوبين" و مكداس الدم " الهيماتوكريت" و تعداد كريات الدم الحمراء وتعداد الصفيحات الدموية بين الطلاب الذكور البالغين الذين يعيشون فوق مستوى سطح البحر و اولئك الذين يقطنون تحت مستوى سطح البحر ، وذلك في دراسة تجرى للمرّة الأولى على أولئك الذين يعيشون تحت مستوى سطح البحر في فلسطين، كما وجدنا أن هناك فروقاً ذات دلالة إحصائيّة بين القيم الطبيعيّة المستعملة والمستقاة من المراجع العالميّة وبين القيم الطبيعيّة المستقاة من دراستنا هذه، وذلك في كل من تعداد كريات الدم البيضاء وتعداد كريات الدم الحمراء والهيموجلوبين و معدل حجم كريات الدم الحمراء MCV و تعداد الصفيحات الدمويّة Plts، الأمر الذي يستدعي العمل على إيجاد قيم طبيعية خاصّة بهذه الفئة المدروسة خاصّة وبالشعب الفلسطيني بشكل عام.

تأثير الإقامة تحت مستوى سطح البحر على فحص تعداد الدم الكامل (CBC)

الدكتور المشرف: الأستاذ خالد اليونس

الباحث: جبر جميل إبراهيم حج علي

الملخص

على المرتفعات العالية ينخفض الضغط الجوي فينخفض توفّر الأكسجين في الهواء مؤديا إلى حالة من نقص الأكسجة في الشرايين والأنسجة الحيوية، فيزداد تبعاً لذلك إفراز هرمون " الإريثروبوييتين" من الكِلية، ويقوم هذا الهرمون بتحفيز إنتاج خلايا الدم الحمراء و تصنيع خضاب الدم (الهيموجلوبين)، وتحصل هذه العمليات بآليات حيوية معقّدة تهدف للتأقلم مع الوضع الجديد وتعويض النقص الحاصل في نقل الأكسجين إلى أنسجة الجسم. هناك العديد من الدّراسات التي تصف عمليات التأقلم والتكيّف على المرتفعات العالية وتأثير ذلك على قيم فحص تعداد الدم الكامل CBC، معظم هذه الدراسات أثبتت أن هناك زيادة في تركيز خضاب الدم " الهيموجلوبين" و إفراز هرمون الـــ " إريثروبيوتين" ، ولكن ما زال هناك نقص واضح في المعلومات المتوفرة عن تأثير العيش تحت مستوى سطح البحر على نتائج فحص تعداد الدم الكامل CBC.

هدفت هذه الدّراسة من جهة إلى تقييم نتائج فحص تعداد الدم الكامل (CBC) لدى أولئك الذين يعيشون تحت مستوى سطح البحر بحوالي 300 متر ومقارنة نتائجهم مع أولئك الذين يقطنون على إرتفاع حوالي 900 متر عن مستوى سطح البحر، وذلك للمرّة الأولى في فلسطين، كماهدفت هذه الدّراسة من جهة ثانية إلى تقييم إمكانيّة الإستمرار في الإعتماد على القيم الطبيعية لفحص الدم CBC والمتوفّرة في الأبحاث والدراسات العالمية في الحكم على

نتائج هذا الفحص للشعب الفلسطيني فيما إذا كان طبيعيّاً أم غير طبيعي، و قد قمنا من أجل ذلك بمقارنة معدّلات نتائج الفحص التي حصلنا عليها في دراستنا مع المعدّلات الموجودة في المراجع العالمية.

تم إجراء هذه الدراسة خلال شهر شباط من سنة 2013 ، حيث قمنا بإختيار عينة عشوائية من طلاب الصّفين الحادي عشر والثاني عشر الذكور من أربعة مدارس، إثنتين في مدينة أريحا الواقعة تحت مستوى سطح البحر وإثنتين في مدينة رام الله، وتراوحت بذلك أعمار الطلاب المدروسين ما بين 16 – 19 سنة، وقد تم توزيع إستبيان على 400 طالب في كلا المدرستين تم إختيار 320 منهم بعد موافقة أولياء أمورهم، وبعد أخذ عينات الدم وفحصها تم إستبعاد 23 نتيجة ليتم إجراء الدراسة على 297 نتيجة طالب منهم 146 في أريحا و 151 في رام الله باستخدام برنامج SPSS وفحص t– test لحساب الفرق بين معدّلين.

وقد أشارت النتائج إلى وجود فروق ذات دلالة أحصائية بين الطلاب في أريحا و رام الله في تعداد خلايا الدم الحمراء والهيموجلوبين و مكداس الدم (الهيماتوكريت) بوجود زيادة لصالح أولئك الذين يقيمون على إرتفاع 900 متر عن سطح البحر ، بينما كان هناك زيادة ذات دلالة إحصائية في تعداد الصفيحات الدمويّة لدى أولئك القاطنين على مستوى 300 متر تحت مستوى سطح البحر.

ومن جهة ثانية أظهرت النتائج وجود فروق ذات دلالة إحصائية بين القيم الطبيعية المستخدمة لفحصCBC والموجودة في المراجع العالميّة وبين القيم الطبيعية المستقاة من عينة الدراسة

التي قمنا بها وذلك في كل من رام الله وأريحا، الأمر الذي يبرر من وجهة نظرنا الحاجة للعمل على تأسيس قيم طبيعية خاصة بالشعب الفلسطيني من هذه الفئة العمريّة خاصّة و لجميع البالغين من الذكور بشكل عام.

الخلاصة: لقد وجدنا أنّ هناك فروقاً ذات دلالة إحصائيّة في قيم كل من خضاب الدم "الهيموجلوبين" و مكداس الدم " الهيماتوكريت" و تعداد كريات الدم الحمراء وتعداد الصفيحات الدموية بين الطلاب الذكور البالغين الذين يعيشون فوق مستوى سطح البحر و اولئك الذين يقطنون تحت مستوى سطح البحر ، وذلك في دراسة تجرى للمرّة الأولى على أولئك الذين يعيشون تحت مستوى سطح البحر في فلسطين، كما وجدنا أن هناك فروقاً ذات دلالة إحصائيّة بين القيم الطبيعيّة المستعملة والمستقاة من المراجع العالميّة وبين القيم الطبيعيّة المستقاة من دراستنا هذه، وذلك في كل من تعداد كريات الدم البيضاء وتعداد كريات الدم الحمراء والهيموجلوبين و معدل حجم كريات الدم الحمراء MCVو تعداد الصفيحات الدمويّة Plts، الأمر الذي يستدعي العمل على إيجاد قيم طبيعية خاصّة بهذه الفئة المدروسة خاصّة وبالشعب الفلسطيني بشكل عام.

Abstract

Reduction in oxygen partial pressure in the air at high altitude leads to reduced oxygen saturation in the arteries and results in erythropoietin production, which stimulates erythropoiesis to restore the appropriate oxygenation status. There are many studies describing the acclimatization to high altitude and its effect on Complete Blood Count (CBC) parameters and on exercise. Most of these studies proved the increase in Hemoglobin (Hgb), erythropoiesis and erythropoietin secretion, while there is lack of available information about the effect of being below sea level on CBC test results. This study aimed to evaluate the CBC parameters of people who live below sea level, for the first time in Palestine, in comparison with those who live above sea level. Moreover, it is expected by the end of this study that we will be able to verify the applicability of the reference ranges that have been adopted from other sources and to assess if we need to establish new reference ranges for people living in Jericho (about 300 meters below sea level) and Ramallah (about 900 meters above sea level).

The study was conducted in February, 2013, where four secondary schools were chosen for the study: two in Jericho and two in Ramallah. Three hundred and twenty participants were randomly chosen from eleventh and twelfth grade male students during this study, where the age of students ranged from 16 to 19 years old.Twenty three of them were excluded as they did not fit the given criteria. Blood samples were collected from the rest two hundred ninety seven participants, and analyzed for CBC. CBC data and questionnaires were analyzed using t-test between two means for independent samples. Results for the differences between means showed that Red Blood Cell counts ($P=0.005$), Hgb ($P=0.001$), and Hematocrit ($P=0.002$) have mean values which are statistically higher among those who live about 900 meter above sea level than among those who live about 300 meter below sea level, while Platelet count (PLT) was significantly higher in those who live below sea level ($P< 0.001$).

Results of t-test for reference ranges showed that CBC reference ranges of Palestinians are different in comparison with the applied reference ranges adopted from published reports. Almost all CBC parameters in our study for both groups in Ramallah and Jericho differ significantly from those in the international studies. This justifies the need to establish our own reference ranges for this age group and for adult male population in general.

In conclusion, we found significant difference in hematological parameters (Hgb, Hct, RBC count, and platelet count) in healthy adult students living above and below sea level in a representative population sample, which is also the first study from people living below sea level in Palestine.