

**“CORRELATION OF HAEMATOLOGICAL PARAMETERS WITH
BODY MASS INDEX AMONG THE STUDENTS OF RIPANS”**

BY

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CHAPTER 1

INTRODUCTION

The body mass index (BMI) is the most widely used parameter in epidemiological studies, usually in detection of population at risk of obesity/malnutrition, and also can say that the metric currently in use for defining anthropometric height/weight characteristics in adults and for classifying them into groups. The common interpretation is that it represents an index of an individual's fatness. It also is widely used as a risk factor for the development of or the prevalence of several health issues. In addition, it is widely used in determining public health policies. The BMI has been useful in population-based studies by virtue of its wide acceptance in defining specific categories of body mass as a health issue ⁽¹⁾.

Body mass index is a person's weight in kilograms divided by the square of height in meters. BMI is an inexpensive and easy screening method for weight category—underweight, healthy weight, overweight, and obesity⁽²⁾

If a person is underweight, their body may not be getting the nutrients it needs to build healthy bones, skin, and hair. Related symptoms or signs can include osteoporosis, anaemia, feeling tired, and Irregular periods.⁽³⁾

Being overweight or obese can have detrimental effects on one's health. Serious health effects from carrying excess fat include type 2 diabetes, musculoskeletal conditions including osteoarthritis, cardiovascular illness (heart disease and stroke), and some malignancies (colorectal, breast, and endometrial). Premature death and significant disability are caused by these conditions.

The good news is that overweight and obesity are largely preventable. Finding an energy balance between calories utilized and calories consumed is essential for success.

People can increase their diet of fruits and vegetables, as well as legumes, whole grains, and nuts, and decrease their intake of sugars in order to achieve this aim. They can also restrict their energy intake from total fats and change their fat consumption from saturated to unsaturated fats. In order to enhance the amount of calories burned, individuals can raise their physical activity levels by aiming for at least 30 minutes of consistent, moderate-intensity exercise most days⁽⁴⁾.

Overweight or obesity is defined as a weight that exceeds what is healthy for a particular height. The Body Mass Index is a screening method used to check for obesity and overweight.

Index of Adult Body Mass:-

A person's weight in kilograms divided by their height in meters squared is their BMI. High body fatness may be indicated by a high BMI.

Use the Adult BMI Calculator or this BMI Index Chart to obtain your BMI by entering your height and weight.

- Your BMI is considered underweight if it is less than 18.5.
- Your BMI is within the healthy weight range if it is between 18.5 and less than 25.
- If your BMI is between 25.0 and less than 30, you are considered overweight.
- Your BMI is considered obese if it is 30.0 or greater ⁽⁵⁾.



Figure.1. Adult Body Mass Index

BMI Formulas

In metric units, using kg and meters:

$$\text{BMI} = \frac{\text{weight in kg}}{\text{height}^2 \text{ in m}}$$

In metric units: $\text{BMI} = \text{weight (kg)} \div \text{height}^2 \text{ (meters)}$

In US units: $\text{BMI} = \text{weight (lb)} \div \text{height}^2 \text{ (inches)} * 703$ ⁽⁷⁾.

BMI surveillance data can be used to:

- Describe trends in weight status over time among populations and/or sub-populations in a school, state, or country;
- Raise awareness of the severity of weight problems in the targeted populations among students, health professionals, community members, and policy makers.
- Help practitioners and school staff target prevention and treatment programs by identifying the demographic or geographic subgroups most at risk of obesity;
- Encourage the improvement of policies, practices, and services to prevent and treat obesity in children and adolescents; and
- Track the results of school-based physical activity and nutrition programs and policies.
- Track advancements made toward national health goals (such as the U.S. Healthy People 2010 targets) or pertinent state or local health goals concerning childhood obesity.

BMI measurement has attracted attention across the nation as a potential approach to address obesity among youth.⁽⁸⁾

BLOOD

The average human possesses five litres of blood. Blood transport oxygen from lungs to tissues; clears tissues of carbon dioxide; transport glucose, proteins, and fats; and moves wastes to liver and kidneys. The liquid portion is plasma, which transport coagulation enzymes that protect vessels and maintain the circulation. plasma carries and nourishes blood cells. There are three families of blood cells: red blood cells, white blood cells, and platelets.

Haematology is the study of blood cells. By expertly staining, counting, analyzing and recording the appearance of all three types of cells, the clinical laboratory scientist is able to predict, detect and diagnose blood diseases and many systemic diseases that affect blood cells. Physician rely on haematology laboratory test results to select and monitor therapy for these disorders⁽⁹⁾. Blood act as a pathological reflector of the status of the exposed animals to toxicants and other conditions.⁽¹⁰⁾

The hematological parameters are elements of blood which include erythrocytes, leucocytes and platelets and these parameters are widely used as clinical indicators of health and diseases⁽¹¹⁾

1. RED BLOOD CELLS (RBCs) - also known as erythrocytes, are anucleate biconcave cells filled with a reddish protein, haemoglobin, which transports oxygen and carbon dioxide. RBCs appear pink to red and measures 6-8µm in diameter with a pallor zone covering one third of their center, reflecting their biconcavity and it's a vital component of blood⁽¹²⁾

The erythrocytes or red blood cells are defined by the following quantitative values:

- a) Hematocrit (Hct) or Volume of packed red cells –Hematocrit measures the volume of packed red blood cells (RBC) relative to whole blood. Hence, it is also known and reported as a packed cell volume (PCV). It is a simple test to identify conditions like anaemia or polycythemia and also to monitor response to the treatment. A glass tube and a centrifuge machine are sufficient to measure HCT. After centrifugation, the component of blood separates into three distinct parts. From below upwards, the layers are - a layer of red blood cells (RBC), a layer of white blood cells (WBC) and platelets, and a layer of plasma at the top. This method of determining HCT by Wintrobe hematocrit tube is known as the “macro-hematocrit” method. A Wintrobe tube is a 110 mm long, narrow glass tube that has graduations going from 0 to 100 mm in both ascending and descending directions. The "micro-hematocrit" approach, which substitutes a tiny capillary tube for a Wintrobe hematocrit tube, has superseded this technique. Both the amount of blood needed and the amount of time needed for the test are reduced. It is advantageous for patients (such as paediatric patients or those with hypovolemia) from whom blood collection is challenging. Nonetheless, the test's fundamental idea is still the same as that of the "macro-hematocrit" approach. The lengths of the packed RBC layer and the overall length of cells and plasma are divided to calculate the HCT. It has no unit because it is a ratio. Upon multiplying the ratio by 100, the precise value, which is the recognized HCT reporting format. An adult male's normal HCT ranges from 40% to 54%, while a female's ranges from 36% to 48%. While these two techniques are still utilized in certain primary care and medical education settings, an automated

analyzer that generates HCT results in addition to complete blood counts has largely supplanted them in most settings⁽¹³⁾.

- b) Haemoglobin (Hb) concentration – Hemoglobin is the protein contained in red blood cells that is responsible for delivery of oxygen to the tissues. To ensure adequate tissue oxygenation, a sufficient hemoglobin level must be maintained. The amount of hemoglobin in whole blood is expressed in grams per decilitre (g/dl). The normal Hb level for males is 14 to 18 g/dl; that for females is 12 to 16 g/dl. Anemia is the condition when the patient's hemoglobin level is low. An overabundance of red blood cells causes an erythrocytosis, which raises hemoglobin levels above normal⁽¹⁴⁾

Hemoglobin measurement relies on a weak solution of potassium cyanide and potassium ferricyanide, called Drabkin's reagent. An aliquot of whole blood is mixed with a measured volume of Drabkin's reagent, hemoglobin is converted to stable cyanmethemoglobin (hemiglobincyanide), and the absorbance or color intensity of the solution is measured in a spectrophotometer at 540 nm wavelength. The color intensity is compared with that of a known standard and is mathematically converted to hemoglobin concentration. Modifications of the cyanmethemoglobin method are used in most automated applications, although some automated hematology profiling instruments replace it with a formulation of the ionic surfactant (detergent) sodium lauryl sulfate to reduce environmental cyanide.

- c) Red cell count - Red blood cells may be counted using a microscope, hemocytometer and a glass pipette designed to provide the dilution, was used routinely until the advent of automation and still available from clinical laboratory supply companies. The diluted blood was transferred to a counting chamber and then observed and counted RBCs in selected areas of the hemocytometer, applied a mathematical formula and reported RBC count in cells per micro litre

d) Red Blood Cell Indices -The mean cell volume (MCV), mean cell hemoglobin (MCH), and mean cell hemoglobin concentration (MCHC) are the RBC indices. These are calculated to determine the average volume and hemoglobin content and concentration of the red blood cells

in the sample. In addition to serving as a quality control check, the indices may be used for initial classification of anemia.

i) Mean Corpuscular Volume:- The MCV is the average volume of the red blood cell, expressed in femtoliter (fl), or 10^{-15} L:

$$\text{MCV} = \frac{\text{HCT (\%)} \times 10}{\text{RBC count (} 10^{12} \text{/L)}}$$

The reference interval for MCV is 80 to 100 fl. RBCs with an MCV of less than 80 fl are microcytic; those with an MCV of more than 100 fl are macrocytic.

ii) Mean Corpuscular Hemoglobin (MCH)- The MCH is the average weight of hemoglobin in a red blood cell, expressed in picogram (pg), or 10^{-12} g:

$$\text{MCH} = \frac{\text{HGB (g/dl)} \times 1}{\text{RBC count (} 10^{12} \text{/l)}}$$

The reference interval for adults is 26 to 32 pg. The MCH generally is not considered in the classification of anemia.

iii) Mean Corpuscular Hemoglobin Concentration (MCHC)- The MCHC is the average concentration of hemoglobin in each individual red blood cell. The units used are grams per decilitre (formerly given as a percentage):

$$\text{MCHC} = \frac{\text{HGB (g/dl)} \times 100}{\text{HCT (\%)}} .$$

Values of normochromic red blood cells range from 32 to 36 g/dl; values of hypochromic cells are less than 32 g/dl, and values of “hyperchromic” cells are greater than 36 g/dl. Hypochromic red blood cells occur in thalassemia, iron deficiency, and other conditions

iv) Red Cell Distribution Width (RDW) – RBC distribution width, expresses the degree of variation in RBC volume. Extreme RBC volume variability is visible on the Wright-stained

blood film as variation in diameter and is called anisocytosis. The RDW is based on the standard deviation of RBC volume and is routinely reported by automated cell counters.

2) White blood cells or leukocytes-: WBC are a loosely related category of cell types dedicated to protecting their host from infection and injury. WBCs are transported in the blood from their source, usually bone marrow or lymphoid tissue, to their tissue or body cavity destination. WBCs are so named because they are nearly colorless in an unstained cell suspension. WBCs may be counted visually using a microscope and hemocytometer. The technique is the same as RBC counting, but the typical dilution is 1:20, and the diluent is a dilute acid solution. The acid causes RBCs to lyse or rupture; without it, RBCs, which are 500 to 1000 times more numerous than WBCs, would obscure the WBCs. The WBC count ranges from 4500 to 11,500/ml. Visual WBC counting has been largely replaced by automated hematology profiling instruments, but it is accurate and useful in situations in which no automation is available. Medical laboratory professionals who analyze body fluids such as cerebrospinal fluid or pleural fluid may employ visual WBC counting.

3) Platelets or thrombocytes - platelets are true blood cells that maintain blood vessel integrity by initiating vessel wall repairs. Platelets rapidly adhere to the surfaces of damaged blood vessels, form aggregates with neighboring platelets to plug the vessels, and secrete proteins and small molecules that trigger thrombosis, or clot formation. Platelets are the major cells that control hemostasis, a series of cellular and plasma based mechanisms that seal wounds, repair vessel walls, and maintain vascular patency (unimpeded blood flow). Platelets are only 2 to 4 μ m in diameter, round or oval, anucleate (for this reason some hematologists prefer to call platelets "cell fragments"), and slightly granular. Their small size makes them appear insignificant, but they are essential to life and are extensively studied for their complex physiology. Uncontrolled platelet and hemostatic activation is responsible for deep vein thrombosis, pulmonary emboli, acute myocardial infarctions (heart attacks), cerebrovascular accidents (strokes), peripheral artery disease, and repeated spontaneous abortions (miscarriages). The microscopist counts platelets using the same technique used in counting WBCs on a hemocytometer, although a different counting area and dilution is usually used. In this procedure, whole blood, with EDTA as the anticoagulant, is diluted 1:100 with 1% ammonium oxalate to lyse the non nucleated red blood cells. The platelets are counted in the 25 small squares in the large center square (1 mm²) of the hemocytometer using a light

microscope. Automated profiling instruments have largely replaced visual platelet counting and provide greater accuracy.

4) Wintrobe Erythrocyte Sedimentation Rate- When the Wintrobe method was first introduced, the specimen used was oxalate-anticoagulated whole blood. This was placed in a 100-mm column. Today, EDTA-treated or citrated whole blood is used with the shorter column. The shorter column height allows a somewhat increased sensitivity in detecting mildly elevated ESRs. In this procedure use fresh blood collected in EDTA anticoagulant. A minimum of 2 ml of whole blood is needed. After mixing the blood thoroughly, fill a Pasteur pipette using a rubber pipette bulb and Place into the Wintrobe tube. Fill the Wintrobe tube to the 0 mark. Place the tube into a Wintrobe rack (tube holder) and allow to stand undisturbed for 1 hour at room temperature. Record the number of millimeters the red blood cells have fallen. Read the tube from the bottom of the plasma meniscus^(15,16).

1.1 ASSUMPTIONS

1. We may find abnormalities in hematological parameters.
2. Females might have a greater risk than males.
3. There may be findings of hematological parameters difference due to dietary habits and lifestyle of students.
4. Possible findings of difference hematological parameters between overweight and underweight individual.

1.2 HYPOTHESIS

- a. Null Hypothesis (H₀):** There is no significant difference in hematological parameters between underweight and overweight individuals.
- b. Alternative Hypothesis (H₁):** There is a significant difference in hematological parameters between underweight and overweight individuals.

CHAPTER- 2

AIMS AND OBJECTIVES

1. This study is to correlate the hematological parameters with body mass index from healthy students of RIPANS.
2. To furnish the awareness to take necessary action in time for those who have abnormalities in hematological test performed.

CHAPTER-3

REVIEW OF LITERATURE

Review of literature is important in order to gain a better understanding and insights necessary to develop a broad conceptual framework in which problem can be examined. It helps in the formation of specific problems and helps acquaint the investigator to what already in relation to the problem under review and it also provides a basis for assessing the feasibility of the research approach.

This chapter presents a literature review organized into the following sections:

Section I: Literature on correlation of hematological parameters with the Body mass index

Section II: Literature on body mass index and its significance

Section III: Literature on the correlation of white blood cell with BMI

Section IV: Literature on Correlation of red cell indices with BMI

Section V: Literature on correlation of Red blood cells with BMI

Section VI: Literature on correlation of Erythrocytes sedimentation rates with BMI

Section VII: Literature on correlation of hematocrit / Packed cell volume with BMI

Section VIII: Literature on correlation of Platelet with BMI

SECTION I :

Literature on correlation of hematological parameters with the Body mass index.

H.R. Jeong *et al.*,¹⁷, conducted a study on Positive Associations between Body Mass Index and Hematological Parameters, Including RBCs, WBCs, and Platelet Counts, in Korean Children and Adolescents. The levels of hematological parameters (including white blood cells, red blood cells, hemoglobin , hematocrit, and platelets) of 7997 participants (4259 boys and 3738 girls) aged 10–18 years were recorded. The parameters were compared among participants with normal weight, overweight, and obesity. Significantly higher mean levels of

WBCs (7.16 vs. $6.16 \times 10^3/\text{mm}^3$, $p < 0.001$), RBCs (4.90 vs. $4.82 \times 10^6/\text{mm}^3$, $p < 0.001$), Hb (14.07 vs. 13.99 g/dl, $p < 0.05$), Hct (42.31 vs. 41.91% , $p < 0.001$), and platelets (311.87 vs. $282.66 \times 10^3/\text{mm}^3$, $p < 0.001$) were found in the obese than normal weight group, respectively, after adjusting for body mass index (BMI) and sex. BMI SDS had significant positive associations with the levels of WBCs ($\beta = 0.275$, $p < 0.001$), RBCs ($\beta = 0.028$, $p < 0.001$), Hb ($\beta = 0.034$, $p < 0.001$), Hct ($\beta = 0.152$, $p < 0.001$), and platelets ($\beta = 8.372$, $p < 0.001$) after adjusting for age, sex, and socioeconomic factors in a multiple linear regression analysis. A higher BMI was associated with elevated WBC, RBC, Hb, Hct, and platelet counts in children and adolescents. Because higher levels of hematological parameters are potential risk factors for obesity-related diseases, hematological parameters should be evaluated in obese children and adolescents.

Akinbo *et al.*,¹⁸ was conducted a study on the present study evaluated the relationship between body mass index and hematological indices by randomly selecting young adult Nigerians with different haemoglobin electrophoretic patterns within the age group of 17-45 years and mean age of ± 31 years old. 215 participants were enlisted for this study with their BMI and other anthropometric indices measured and grouped into different BMI categories as recommended by the World Health Organization. Hematological indices such as packed cell volume, total and differential white blood cell count, and platelets as well as haemoglobin (Hb) electrophoresis were assessed in relation to their anthropometric measurements using standard methods. We observed a significantly increased neutrophil and platelet counts in the subjects with BMI > 25 kg/m². BMI was also observed to be positively correlated with the neutrophil, monocyte counts and MCV of haemoglobin AS and SS genotype groups in this study. This study showed a higher percentage of overweight and obesity among females, and hematological dyscrasias in mostly the HbSS subjects. Knowledge of the relationship between BMI and hematological indices of apparently healthy individuals within any population is therefore essential in healthcare planning, as a justification for early prognosis and genetic counselling policy strategically reducing the incidence of obesity, its attendant conditions and hemoglobinopathies in Nigeria.

P. Singh *et al.*,¹⁹ conducted a study on total of 300 randomly selected patients, to determine the association of hemoglobin, red blood cell (RBC) count, white blood cell (WBC) count, and platelets with the age, gender, and BMI of patients, and calculated height and weight of the patient after their consent and calculated their BMI. The selected patients were categorized into five age groups from Group A to Group E (20–30 years, 31–40 years, 41–50 years, 51–60

years, and 61–70 years), into males and females (Group A and Group B), also according to BMI into four groups (Group A – BMI <18.5 kg/m², Group B – BMI 18.5–25 kg/m², Group C – BMI >25 kg/m², and Group D – BMI >30 kg/m²). Blood sample was collected from each patient in an ethylenediamine tetraacetic acid anticoagulant and was analyzed using a hematological auto-analyzer. A decline in hemoglobin (HB) levels and RBC count was observed above 30 years, and it decreased more in females. The mean age of obese subgroup was found to be significantly more among males. Whereas, underweight and overweight were found to be significantly more among females. HB, RBC, and platelet count did not show any significant difference among the subgroups of BMI category, but WBC count was found to be adequate in majority of the subjects with normal weight.

L. Jamshidi et al.,²⁰ In this cross-sectional study, a total of 1024 Iranian subjects living in Hamedan include, staff of Islamic Azad University of Hamedan and subjects who referred to Ekbatan hospital in Hamedan during the period of 6 months randomly and staff of Islamic Azad University of Hamedan. The absence of infectious disease was confirmed by a general practitioner. Finally, the samples included 486 subjects, 254 male, and 232 were females. Body mass index was calculated. The average age of the subjects was 34.75 ± 8.1 years. The body mass indexes in 7.6 percent of men and 15.7 of women were greater than 30 (kg/m²). The averages of waist circumference in men and women was 1.04 ± 0.5 and 89.3 ± 10.2 (cm), respectively. Also there seemed to be a significant correlation between waist circumference and the number of platelets in both male and female subjects ($P < 0.0001$); however, only in overweight ($P = 0.005$), and obese women ($P < 0.0001$). The platelet counts increased significantly. Furthermore, there was a positive correlation between BMI and WBC in the obese group ($P < 0.05$).

A prospective, observational clinical study conducted by **TT. Koca.,²¹** on a Does obesity cause chronic inflammation? The association between complete blood parameters with body mass index and fasting glucose. They involved Hospitalized patients who received a physiotherapy program in the Physical Medicine and Rehabilitation Clinic between March-June 2016, and they divided patient into three groups and they found a significant difference in the lymphocyte count, ESR, and NLR values was observed among the three groups ($P = 0.011$; $P = 0.021$; $P = 0.04$). A significant difference in NLR was found between groups 1 and 3 ($P = 0.04$). Between groups 1 and 3, a significant difference in platelet count was noted ($P =$

0.013). On dividing the patients into two groups: normal and overweight/obese, a significant difference in lymphocyte count, glucose, and ESR values was observed ($P= 0.038$; $P= 0.05$; $P= 0.013$). The lymphocyte count, ESR, and glucose values were found to be higher in the overweight group.

J.Vuong *et al.*,²², conducted a study in that participants consisted of male and female volunteers of aged 25–55 sampled in the three NHANES biennial cycles. The three major US races were studied and reference interval diagrams were constructed for each CBC parameter plotted against WC. WBC count, RDW, lymphocyte, neutrophil, and red blood cell count increase with WC. Conversely MCH and MCV decrease.

A. Alrubaie; *et al.*,²³ review a retrospective cross-sectional study re on the Effects of Body Mass Index (BMI) on complete blood count parameters. This conducted in the obesity research and therapy unit at AL-Kindy College of medicine, University of BaghdadIraq. The records included were between January 2018- 2019, which included 200 medical files that possess complete blood count test of male patients aged 18-60 years, who were already diagnosed as overweight and obese according to WHO standards. There were 13 participants with BMI (25-29.9), 60 participants with BMI (30-34.9), 53 participants with BMI (35-39.99) and 74 with $BMI \geq 40$. The laboratory results of complete blood count have shown that 16% (32 patients) were anemic and 84% (168 patients) had normal haemoglobin levels. Among 200 patients, 41(20.5%) of them had leukocytosis ($WBC >10 \times 10^3/\mu L$).

Leptin levels are strongly related to total body fat. It is however not yet clear if leptin is also related to visceral fat accumulation or not. In this study, we investigated whether leptin is also associated with body fat distribution and if this association is different in men and women. Leptin was measured in 143 obese subjects (118 women and 25 men) with a body mass index (BMI) greater than 28. Also weight, skinfolds, waist-to-hip ratio (WHR), fat mass by bioimpedance analysis (BIA) were measured, and abdominal visceral and subcutaneous fat were determined by CT scan. Leptin levels were significantly related with BMI, with fat mass (in kg and percentage body fat) as measured by BIA and skinfolds, and with total abdominal fat mass and subcutaneous fat measured by CT scan. No association was found with visceral fat, waist circumference or WHR. In men and women separately, however, a correlation with visceral fat existed. After correction for total body fat, the correlation remained significant only with subcutaneous fat in women. Multiple regression analyses pointed out that percentage body fat was the most important determinant of leptin for all subjects, while for women subcutaneous

fat was the most important parameter, and for men alone total abdominal fat. These results suggest that subcutaneous fat seems to be an important factor related to leptin levels. **M. Wauters *et al.*,²⁴**

The Changes in body fat mass in a large number of hemodialysis patients is unknown. Body fat mass and lean body mass were measured by dual x-ray absorptiometry (DXA) in 561 patients with hemodialysis duration less than 180 months (62.3 +/- 11.5 years old; mean +/- SD). Fat mass tended to increase during the first 3 years of hemodialysis, and it tended to decrease thereafter. Between hemodialysis duration and the fat mass index, there was a significant positive correlation within the first 36-month period of hemodialysis ($r = 0.124$; $P < 0.05$; $n = 245$), and a significant negative correlation during the period of 36 to 180 months. ($r = -0.192$; $P < 0.001$; $n = 316$). There was no tendency of change in the lean body mass index. Considering the results together with the authors previous prospective study results, which show significant fat mass increase in the first year of hemodialysis, the present cross-sectional study may suggest that fat mass gradually increases in the first 3 years and decreases thereafter. Fat mass is suggested to be a nutritional parameter in hemodialysis patients. **E. Ishimura;*et al.*,²⁵**

This research was aimed to determine and compare the plantar pressure distribution within standing and walking of obese and control adults. A total of 100 feet in 50 study participants. Subjects were divided into two groups based on their body mass index values: non-obese, and class 1 obese ($n=25$ each). Pedobarographic measurements were obtained in static and dynamic conditions while subjects were in both of stance and gait phases. The data were analysed and compared between the groups and the correlation of body mass index with the pedobarographic parameters was assessed. The findings of this study shown that static pedobarographic assessment concluded with significant increase of forefoot peak pressure, total plantar force and total contact area in the class 1 obese group, whereas only middle foot peak pressure was found in higher values to be higher as a dynamic pedobarographic measure in class 1 obese people compared to controls. Body mass index was found to positively correlate with both total contact area ($r=0.33$, $P=0.019$) and total plantar force ($r=0.50$, $P=0.000$) among the static measures. Of the dynamic pedobarographic measures, only the middle foot peak pressure ($r=0.32$, $P=0.025$) showed a positive connection with body mass index. This study may be a first step to evaluate the effect of different obesity categories on the plantar pressure values. Further studies are needed to investigate the effect of different obesity grades. **Birtane Murat *et al.*,²⁶**

Ibrahim E. Ertas *et al.*,²⁷ was conducted cross-sectional study design, CRP was measured by a high sensitive immunoturbidimetric method between 24 and 40 weeks of gestation in normotensive controls, in mild and severe pre-eclamptic patients. The HS-CRP values of severe pre-eclamptic patients were substantially higher than those of mild patients and controls in the study group with BMI < 25 kg/m² ($P < 0.001$) after all three patient groups' gestational ages [24°/7–27,6/7 28°/7–33,6/7 34°/7–406/7] and BMI were corrected for. Only individuals with severe pre-eclamptic symptoms between 28°/7 and 336/7 weeks of gestation had substantially higher HS-CRP values in the study group with BMI $\geq$ 25 kg/m² compared to the control and moderate pre-eclamptic groups ($P < 0.001$). Sub-grouping the patients into high (≥ 9.66 mg/L) and low (< 9.66 mg/L) HS-CRP groups revealed statistically significant differences in the adverse outcomes for hemolysis, elevated liver enzymes, low platelet count (HELLP) syndrome, and intrauterine growth-restricted baby ($P = 0.004$ and $P < 0.001$, respectively). In individuals with a BMI of less than 25 kg/m² during the third trimester, an elevated level of HS-CRP is a valuable criterion in assessing the degree of clinical risk of pre-eclampsia.

A. Anık *et al.*,²⁸ a total of One-hundred and thirty overweight, 341 obese, 188 morbidly obese children and 110 controls were enrolled in the study, and it was found that WBC, neutrophil, lymphocyte, and monocyte counts were highest in the morbidly obese group followed by the obese, overweight, and healthy groups, respectively. Platelet count, PCT, and PDW were significantly higher in the morbidly obese, obese, and overweight groups compared to the healthy group. However, there was no significant difference between the groups in terms of MPV, NLR, and PLR. WBC, neutrophil, lymphocyte, platelet, PCT, ALT, and triglyceride levels were higher in children with insulin resistance than those without insulin resistance. There was a positive correlation with the neutrophil, lymphocyte, monocyte count, and PCT value, and a negative correlation with the PDW value. Moreover, there was a positive correlation between the HOMA-IR and WBC, neutrophil, lymphocyte count, and PCT. Additionally WBC, neutrophils, lymphocytes, monocytes, platelets, and PCT values increase in childhood obesity, which could point towards low-grade chronic inflammation and this increase in WBC, neutrophils, lymphocytes, and PCT value may be associated with insulin resistance.

In this cross-sectional, retrospective study; a total of 223 participants' data (104 female and 119 male) was included, aged between 18-65 years who presented for a routine check-up or obesity was collected and subjects were grouped as normal weight, overweight, obese and

morbidly obese accordingly BMI. Persons' smoking habits were calculated as pack/years. Smoking status and BMI groups were compared to CBC findings and ratios derived from these findings. Results were noted that BMI was found to have a statistically significant positive linear correlation with lymphocyte number, PDW, SII and RDW ($p < 0.05$), and an extremely significant positive linear correlation ($p < 0.01$) was found between BMI and WBC, neutrophil count, PCT and platelet count. When BMI was not considered and 135 smokers were compared to 88 non-smokers, leukocytes and neutrophil counts were found to be higher in smokers ($p < 0.05$). The study has found that WBC, neutrophil count, lymphocyte count, platelet count, PCT, PDW and SII are significantly affected by BMI status. **Y. Furuncuoğlu; et al.,** ²⁹.

K.Meena,³⁰ conducted a cross sectional study among hypertensive patients. Relevant clinical data was recorded in a structured Proforma. Complete hemogram, blood pressure and body mass index was recorded. The findings of this study shown that comparative mean Hb among male was statistically significant ($p= 0.024$) and ($p= 0.189$), non significant among female. Comparative mean RBC count among male was statistically non significant ($p= 0.437$) and ($p= 0.783$) non-significant among female. Comparative mean PCV among male was statistically significant ($p= 0.007$) and non significant ($p= 0.321$) among female subjects. Comparative mean MCV among male was ($p= 0.296$) and ($p= 0.310$) among female statistically non significant. Comparative mean RDW among male was statistically non significant ($p= 0.449$) and non significant ($p= 0.180$) among female subjects. It was found that Hb and PCV increases with an increase in BMI, in hypertensive patients.

SECTION II :

Literature on body mass index and its significance

According to the World Health Organization (WHO), estimates that obesity and overweight cause around three million deaths globally each year. In addition, people with high BMIs frequently report feeling better physically and psychologically after losing excess weight, independent of any specific ailment. The range of a person's BMI is regarded normal to be between 18.5 and 25, overweight to be between 25 and 30, and obese to be over 30. If the BMI is less than 18.5, an individual is deemed underweight. Diabetes, arthritis, liver disease, several types of cancer (such as those of the breast, colon, and prostate), high blood pressure (hypertension). **Robert H. Shmerling, MD** ³¹

The body mass index (BMI) is the metric currently in use for defining anthropometric height/weight characteristics in adults and for classifying them into groups. The common interpretation is that it represents an index of an individual's fatness. It also is widely used as a risk factor for the development of or the prevalence of several health issues. In addition, it is widely used in determining public health policies. The BMI has been useful in population-based studies by virtue of its wide acceptance in defining specific categories of body mass as a health issue. **F.Q. Nuttall *et al.*,³²**.

The implementation of school-based BMI measurement for surveillance purposes, that is, to identify the percentage of students in a population who are at risk for weight-related problems, is widely accepted; however, considerable controversy exists over BMI measurement for screening purposes, that is, to assess the weight status of individual students and provide this information to parents with guidance for action. Although some promising results have been reported, more evaluation is needed to determine whether BMI screening programs are a promising practice for addressing obesity. Based on the available information, BMI screening meets some but not all of the criteria established by the American Academy of Pediatrics. Schools that initiate BMI measurement programs should evaluate the effects of the program on BMI results and on weight-related knowledge, attitudes, and behaviors of youth and their families; they also should adhere to safeguards to reduce the risk of harming students, have in place a safe and supportive environment for students of all body sizes, and implement science-based strategies to promote physical activity and healthy eating. **A.J. Nihiser *et al.*,³³**.

The study on retrospectively (Jan 2006-dec 2010) aimed to investigate the association of preoperative/postoperative body mass index and prognostic nutritional index with prognosis in patients with stage II/III gastric cancer treated with gastrectomy gastric cancer, in 1868 patients. As results show that Preoperative underweight and low PNI were related to poor prognosis (log-rank $p < 0.001$ for both). There was a positive correlation between preoperative BMI and PNI (mean preoperative PNI: 51.13 [underweight], 53.37 [normal-weight], and 55.16 [overweight]; $p < 0.001$). Preoperative BMI and PNI were independent prognostic factors for disease-free survival along with age and TNM stage ($p < 0.001$ for both). BMI changes from normal-weight to underweight and from overweight to normal/underweight were related to poor prognosis (log-rank $p = 0.021$ and $p = 0.013$, respectively). PNI changes were related to prognosis in both the preoperative low and high PNI groups ($p < 0.001$ and $p = 0.019$, respectively). However Preoperative BMI and PNI and their postoperative changes are related to prognosis in patients with stage II/III gastric cancer. **S.H.Park *et al.*,³⁴**.

L.N. Handlos *et al.*,³⁵ sample of 245 overweight adult Kenyans (body mass index (BMI) ≥ 25 kg/m²) was analysed. Mean age of study participants was 42.1 years (SD = 9.6) and 26.5% of the participants were men. The median BMI was 28.6 kg/m² (Q1 = 26.3; Q3 = 31.3). Of the six anthropometric variables tested, WC and VAT thickness had the strongest negative association with the metabolic profile ($\beta = 0.17$ (0.09; 0.24) and 0.15 (0.08; 0.23), respectively).

The study was conducted by **V. Tejashwini Basarigidad *et al.*,**³⁶ in a total of 200 participants comprising 100 males and 100 females aged between 18 to 30 years in this study they observed PCV is statistically increased in overweight and obese individuals as compared to other BMI groups in both males and females. Total leucocyte count was significantly higher in overweight and obese subjects when compared to normal subjects. We found no change in Haemoglobin concentration and RBC count in all BMI groups.

SECTION III:

Literature on the correlation of white blood cell with BMI:-

T. Nishida *et al.*,³⁷ conducted a study on total of 114 women aged 20–39 who participated in an annual health checkup for residents in a city in Aichi, Japan. Data from a questionnaire, physical examination, and blood tests were analyzed in relation to women who were severely underweight [body mass index (BMI) ≤ 17.5 kg/m²], slightly underweight ($17.5 < \text{BMI} < 18.5$ kg/m²), of normal weight ($18.5 \leq \text{BMI} < 25$ kg/m²), and obese (BMI ≥ 25 kg/m²). Lymphocyte count tended to be lower with a decrease in BMI. The prevalence of low lymphocyte count of $<1,500/\text{mm}^3$ increased in underweight women. In women who had restricted food intake for weight loss, leukocyte count, and total serum protein, and lymphocyte count were lower. A multivariate logistic regression analysis showed the association of low lymphocyte count to being severely underweight [odds ratio (OR): 1.95; 95% confidence interval (CI): 1.07–3.56] and to restricted food intake for weight loss. This study suggests that being severely underweight and on restricted food intake for weight loss in adult women can be risk factors for low lymphocyte count, an indicator of malnutrition. It is important for young women to maintain BMI >17.5 kg/m² and not to restrict food intake when of normal weight or underweight in order to prevent malnutrition.

The study was conducted by **J.A. Kim,**³⁸ a total of 102 female obese adolescent subjects were analyzed. Anthropometry, WBC count, blood pressure, fasting plasma glucose, lipid profiles,

and fasting insulin concentrations were measured. Subcutaneous adipose tissue (SAT) and visceral adipose tissue areas were calculated using computed tomography. Mean values of waist circumference ($P < .05$), total adipose tissue (TAT) ($P < .01$), and SAT ($P < .01$) were significantly higher in the group with the higher WBC count. The WBC count was positively related to body mass index, waist circumference, and TAT and SAT areas after adjustment for age and metabolic risk factors ($P < .01$). Among the WBC components, neutrophils were positively associated with body mass index ($P < .01$), waist circumference ($P < .01$), and TAT ($P < .05$). The WBC count escalated with a graded increase in TAT or SAT (P for trend $< .01$). Our findings collectively indicate that the WBC count is positively related to abdominal adiposity in female obese adolescents. Moreover, this relationship is more distinguishable with subcutaneous than visceral adiposity.

The study was directed by **T. Nishida *et al.***,³⁹ to investigate Association Between Underweight and Low Lymphocyte Count as an Indicator of Malnutrition in Japanese Women, by measuring serum albumin, prealbumin, and lymphocyte count as indicators of nutritional status. The subjects were 912 women aged 19–39 years who participated in an annual health checkup for residents in a city of Aichi prefecture, Japan. Questionnaire data, physical measurements, and blood tests were analyzed in relation to weight categories of underweight (body mass index [BMI] < 18.5 kg/m²), normal (BMI ≤ 18.5 – < 25 kg/m²), and obese (BMI ≥ 25 kg/m²). Lymphocyte counts were significantly lower in the underweight group. A multivariate logistic regression analysis showed an association of low lymphocyte count ($< 1500/\mu\text{l}$) with underweight (odds ratio [OR] 1.96, 95% confidence interval [CI] 1.35–2.83). Low prealbumin (< 20 mg/dl) was associated with weight loss (OR 1.42, 95% CI 1.00–2.02) but not with underweight. Albumin was not lower in the underweight group. The prevalence of low lymphocyte count was higher by 35% among underweight women who lost weight of ≥ 1 kg in the past 3 months and higher by 50% among those who lost weight of ≥ 2 kg.

In this retrospective study, with a cut-off point of 30, the BMI was utilized to determine obesity in the 281 study participants (157 were obese and 127 were not). The two groups' white blood cell (WBC) counts differed statistically significantly (p -value < 0.001). Furthermore, of individuals with leukocytosis, 88.9% were obese and 11.1% were not. A positive association ($r = 0.391$, p -value < 0.001) has been seen between the BMI and the WBC count. The cause of leukocytosis is neutrophilia, which has a mean of $8.3 \times 10^9 \pm 3$. (**S. Sait; *et al.***,⁴⁰

This study was directed by **O.I. Ajayi *et al.***,⁴¹ to evaluated the relationship between body mass index and hematological indices by randomly selecting young adult Nigerians with different haemoglobin electrophoretic patterns within the age group of 17-45 years and mean age of ± 31 years old. 215 participants were enlisted with their BMI and other anthropometric indices measured and grouped into different BMI categories as recommended by the World Health Organization. Hematological indices such as packed cell volume, total and differential white blood cell count, and platelets as well as haemoglobin (Hb) electrophoresis were assessed in relation to their anthropometric measurements using standard methods. We observed a significantly increased neutrophil and platelet counts in the subjects with BMI > 25 kg/m². BMI was also observed to be positively correlated with the neutrophil, monocyte counts and MCV of haemoglobin AS and SS genotype groups in this study. This study showed a higher percentage of overweight and obesity among females, and hematological dyscrasias in mostly the HbSS subjects. Knowledge of the relationship between BMI and hematological indices of apparently healthy individuals within any population is therefore essential in healthcare planning, as a justification for early prognosis and genetic counselling policy strategically reducing the incidence of obesity, its attendant conditions and haemoglobinopathies in Nigeria.

The study was conducted in a total of 47,678 participants were monitored from (2007- 2016). An automated hematological analyzer was used to determine the WBC count and classified obesity and type 2 diabetes using the World Health Organization's guidelines. This shows the associations between obesity status, WBC count, and the incidence of T2D were examined using adjusted Cox proportional hazards regression models. 1463 participants experienced T2D over the roughly nine-year follow-up period. When comparing non-obese participants with elevated WBC count, obese participants with low WBC count, and non-obese participants with elevated WBC count to obese participants with low WBC count, the hazard ratios (95% confidence interval) of T2D for these groups were 1.22(1.03–1.44), 1.37(1.12–1.66), and 0.99(0.83–1.20), respectively, in the final multivariate model. According to this study, the WBC count can be used as a marker to determine whether obesity raises the risk of type 2 diabetes. **A. Gu Yeqing; *et al.***,⁴²

The study was conducted by **S. Kashima, *et al.***,⁴³ in total, 9,706 participants were enrolled with WBC < 10*10⁹/L and CRP < 10 mg/L using data from the Yuport Medical Checkup Center. During study period, 272 men (5.5%) and 113 women (2.4%) progressed to diabetes.

The progression to diabetes was predicted by both increased baseline levels of WBC count [adjusted HR = 1.29 (95% CI: 1.04–1.60)] and CRP level [1.39 (1.10–1.74)]. In addition, the elevated HRs of either or both higher WBC and CRP levels were observed across four subgroups of body mass index (BMI), including low BMI, and people who had at least one occurrence of dyslipidemia. As a result increased WBC counts and CRP levels were predictive for type 2 diabetes and the combination augmented the risk of diabetes, regardless of whether the BMI was high or low.

This study was conducted by **T. Umehara *et al.***,⁴⁴ to investigate whether components of peripheral blood leukocyte are associated with clinical symptoms in 123 newly patients with de novo PD, who had no focal and systemic inflammatory diseases. Altered DLC and DLC associated peripheral inflammatory biomarkers were associated with PD related symptoms even though there was no sign of clinical inflammation. After controlling for covariables, olfaction and body mass index (BMI) were inversely associated with percentage of neutrophil, neutrophil to lymphocyte ratio, derived neutrophil to lymphocyte ratio, and positively associated with percentage of lymphocyte, lymphocyte to monocyte ratio. Patients with tremor-dominant or mixed type had lower peripheral inflammatory indices than those with akinetic rigid type.

This observational study was carried out in the Department of Physiology, Mamata Medical College, Khammam, Telangana from August 2019 to March 2020. A total of 200 clinically healthy volunteers, aged group of 20–60 years participated. Individuals with a history of smoking cigarettes/bidis daily for at least 12 months were considered as smokers. Another 100 non-smokers of the same age group were included separately in this study as a control group. TLC, DLC and other parameters were analysed using standard methods. Results shown that no significant difference between the baseline demographic parameters between the smokers and nonsmokers ensures optimum comparison avoiding bias. The difference between TLC, lymphocyte count, monocyte count, granulocyte count, and oxygen saturation of haemoglobin among smokers and nonsmoker subjects. The study has shown that altered values of TLC and DLC and oxygen saturation of haemoglobin in smokers should be considered during diagnosis, interpretation of result, and treatment of patients. (**D.N. Saranya *et al.***,⁴⁵.

In this study, evaluated the association of WBC count with new-onset diabetic mellitus (DM) in 24,514 non-diabetic subjects during a mean 3.88 years of follow-up. In addition, subgroup analysis of 23,430 subjects with a normal WBC count (range: 3500-10500/ μ l) demonstrated

that increased WBC count was significantly associated with new-onset diabetes after adjusting for demographic, clinical, and biochemical parameters ($p \leq 0.016$). After further adjustment for BMI, this association was attenuated ($p = 0.050$). Results showed that BMI had a significant impact on the relationship between increased WBC count and new-onset diabetes in all study participants. In addition, in the participants with BMI $> 25 \text{ kg/m}^2$, WBC count was positively associated with new-onset DM in the unadjusted and several multivariate models, but this association became insignificant after further adjustment for BMI. Hence, BMI had also a significant impact on the relationship between increased WBC count and new-onset DM in the participants with BMI $> 25 \text{ kg/m}^2$. Finally, in the participants with BMI $\leq 25 \text{ kg/m}^2$, WBC count could not predict new-onset DM, even in the unadjusted model. (C.Y Hsieh *et al.*,⁴⁶.

SECTION IV:

Literature on Correlation of red cell indices with BMI

E .Rossi *et al.*,⁴⁷, performed a cross-sectional analysis of 1488 females and 1522 males 20–79 years of age drawn from the Busselton (Australia) population study to assess the effects of HFE genotype, age, gender, and lifestyle on serum iron and hematology indices. In this study the results shown that, Male C282Y heterozygotes had increased transferrin saturation compared with the wild-type genotype. Neither male nor female heterozygotes had significantly increased ferritin values compared with the wild-type genotype. Younger (20–29 years) wild-type males, but not heterozygous males, had significantly lower ferritin values than wild-type males in the older age groups. Compound heterozygous subjects had increased means for serum iron, transferrin saturation, corpuscular volume, and corpuscular hemoglobin compared with the wild-type genotype, and the males also had increased ferritin values (medians 323 vs 177 $\mu\text{g/L}$; $P = 0.003$). In both male and female wild-type subjects, an increased body mass index was associated with decreased serum iron and transferrin saturation and increased ferritin values. There was a significant increase in ferritin concentrations in both genders with increasing frequency of red meat consumption above a baseline of 1–2 times per week and alcohol intakes $>10 \text{ g/day}$.

The study was conducted by A .Moafi *et al.*,⁴⁸ on a total of 1675 participants, including 514 males and 1161 females, went under clinical observations. The average age was 20.7 ± 3.8 . year Among the students, 18.2% of males and 20% of females were underweight. High systolic blood pressure was more common in the students with BMI $> 25 \text{ kg/m}^2$ ($p < 0.001$). Anemia was seen in 8.7% of females. In males, however, a relation between anemia frequency and

BMI < 18.5 kg/m² was more distinct ($p = 0.002$). There was no association between anemia and students' average test scores.

The study was conducted by **A. Vayá; et al.**,⁴⁹ to determine hematological and inflammatory parameters in morbidly obese patients before bariatric surgery ($n = 142$) and normo-weight controls ($n = 144$). The results shown that RDW was higher in patients than in controls ($p < 0.001$), along with C-reactive protein ($p < 0.001$) and fibrinogen, ($p < 0.001$) while hemoglobin ($p = 0.026$), serum iron ($p < 0.001$), MCH ($p = 0.002$) and MCHC ($p < 0.001$) were lower in morbidly obese patients. The logistic correlation analysis revealed that only low serum iron ($< 62 \mu\text{g/dl}$) and MCH ($< 28.14 \text{ pg}$) levels were associated with $\text{RDW} > 14\%$. These data indicate that the elevated RDW in morbidly obese patients reflects a mild red blood cell hypochromia that does not relate to inflammatory parameters, but to hyposideremia and, consequently, to lower erythrocyte indices, possibly as a result of being on a very low-calorie diet before bariatric surgery. Therefore, RDW should not be considered as an inflammatory marker in this clinical setting.

G.F. von Tempelhoff et al.,⁵⁰ conducted study on a total of 286 healthy women (age: $46.5 \pm 17.6 \text{ y}$; BMI: $25.5 \pm 5.2 \text{ kg/m}^2$) were eligible for inclusion into this prospective evaluation. Pv (mean $\pm$ SD: $1.17 \pm 0.12 \text{ mPa s}$) and RBC aggregation (E0: 12.6 ± 6.3 ; E1: 17.9 ± 7.3) were not significantly correlated with RBC-I but with age and BMI. In contrast, RBC-deformability correlated significantly with MCV and MCH but significantly inversely correlated with MCHC. Deformability significantly increased with age but was unaffected by BMI of women. The correlation between RBC-I and RBC deformability was most remarkable during moderate shear force exposure. Neither haemoglobin nor hematocrit were correlated with RBC deformability or RBC-I.

S.U. Abro, et al.,⁵¹ conducted a Cross-Sectional study (Descriptive) to determine the association of BMI to hemoglobin and red blood cell indices among adolescents. A total of 500 students of MBBS, BDS, DPT of aged 18-25 years were enrolled in this study. The anthropometric measurement was recorded for calculation of the Body Mass Index and Complete blood count i.e Haemoglobin (Hb%), Mean Corpuscular Volume (MCV), Mean corpuscular hemoglobin (MCH), Mean corpuscular hemoglobin concentration (MCHC), Red cell distribution width (RDW) was done and calculated. It was seen that the comparison of Hb%, MCV & RDW had no significant ($p > 0.001$) association of study participants to different categories of Body Mass Index. Mean corpuscular hemoglobin (MCH) ($\chi^2 = 28.278$, $p < 0.001$)

and Mean corpuscular hemoglobin concentration (MCHC)($X^2= 15.659$, $p= 0.016$) were statistically significantly association with different categories of Body Mass Index. The study concluded that Mean corpuscular hemoglobin and Mean corpuscular hemoglobin concentration had statistically significant ($p< 0.001$) association with body mass index (BMI).

M. Koshari, *et al.*,⁵² was conducted a cohort study on Association between RBC Indices, Anemia, and Obesity-Related Diseases Affected by Body Mass Index in Iranian Kurdish Population among 9826 participants aged 35-65 years (5158 females and 4668 males) were recruited in the analyses. A quadratic prediction fit plot investigated the association between RBC indices with BMI and lipid profile. The results shown that higher risk of obesity-related diseases was observed in the fourth quartiles of RBC count, HCT, HGB, and RDW compared to the first quartiles. However, the incidence risk was lower for MCV, MCH, and MCHC. BMI plays an anemia-type dependent role in the relationship. Consideration should be given to the type of anemia in the relationship between BMI and anemia.

A. Klisic *et al.*,⁵³ was conducted, cohort of adolescents ($n= 156$) aged between 16-19 years was included. Iron homeostasis parameters [i.e RBC, hemoglobin , hematocrit , mean corpuscular volume , mean corpuscular hemoglobin , and mean corpuscular hemoglobin concentration and red cell distribution width] and platelet indices [i.e, PLT, mean platelet volume (MPV), plateletcrit (PCT) and platelet distribution width] were determined on the automatic hematology analyzer. Their indexes (i.e, MCV/RBC, MCH/RBC, RDW/MCV, MPV/PLT and PDW/PCT) were calculated. The results shown that Univariate binary regression analysis showed negative associations between body mass index and RDW, PDW, and PDW/PCT, respectively, and positive associations between BMI and MPV and PCT, respectively. However, only RDW kept the independent negative association with BMI in multivariate binary regression analysis [Odds Ratio= 0.734 (0.548-0.983); $p= 0.038$]. In this study it concluded that lower RDW values are the independent predictor of higher BMI in the adolescent population. As a low-cost and simply measured parameter, RDW could be a useful diagnostic biomarker in young populations with overweight/obesity.

This study was aimed to examine the independent relationship between diabetes and iron after controlling for body weight (or obesity) in women. The National Health and Nutrition Examination Survey data from 2015 to 2018 were used in this investigation. Body composition data, HbA_{1c}, iron biomarkers (serum ferritin (SF), soluble transferrin receptor (sTfR), and body iron index (BII)), mean corpuscular volume, mean hemoglobin concentration, red cell

distribution width, and hemoglobin were used. Linear regression models were used to examine how and to what extent body mass index modified the relationship between diabetes and iron status biomarkers. A total of 1834 women aged 20–49 were included in the analysis with a mean (SD) age of 32.2 ± 6.1 years and BMI of 29.5 ± 6.9 kg/m². The mean SF ($p = 0.014$) and BII ($p < 0.001$) were lower, while sTfR ($p < 0.001$) was higher in women with diabetes than those with no diabetes. Mean estimates for MCV and MCH were lower, while RDW ($p = 0.001$) was higher in diabetes patients (all $p < 0.001$). Women with diabetes were more likely to have iron deficiency, anemia, and iron deficiency anemia than those without diabetes (18.1% vs 8.6%, $p < 0.001$), (24.4% vs 8.4%, $p < 0.001$), and (14.8% vs 5.2%, $p < 0.001$), respectively. Among women with obesity, those with diabetes had lower predicted ferritin ($\beta = -0.19$, $p = 0.016$), BII ($\beta = -0.99$, $p = 0.016$), and hemoglobin ($\beta = -0.27$, $p = 0.042$) than those without diabetes. The study shows that diabetes is linked to lower iron stores; this is exacerbated in those with obesity (S. Aguree *et al.*,⁵⁴.

SECTION V:

Literature on correlation of Red blood cells with BMI

M. Wiewiora *et al.*,⁵⁵, the aim of this study was to evaluate the effects of the obesity degree on red blood cell aggregation and deformability. We studied 56 obese patients before weight loss surgery who were divided into two groups: morbid obesity and super obesity. The aggregation and deformability of RBCs were evaluated using a Laser-assisted Optical Rotational Cell Analyzer (Mechatronics, the Netherlands). The following parameters specific to the aggregation process were estimated: aggregation index (AI), aggregation half-time ($t_{1/2}$) and threshold shear rate (γ_{thr}). RBC deformability was expressed as erythrocyte elongation (EI), which was measured at 18.49 Pa and 30.2 Pa shear stresses. Super obese patients presented significantly higher AI ($P < 0.05$) and γ_{thr} ($P < 0.05$) and significantly lower $t_{1/2}$ ($P < 0.05$) compared with morbidly obese individuals

This study investigated the hemorheological characteristics in patients with overweight and/or sleep apnea to identify the main predictor of red blood cell (RBC) abnormalities in sleep apnea patients. Ninety-seven patients were subjected to one night sleep polygraphy to determine their sleep apnea status. Body mass index (BMI) and the apnea/hypopnea index (AHI) were determined for categorization of obesity and sleep apnea status. Blood was sampled for hematocrit, blood viscosity, RBC deformability, aggregation and disaggregation threshold measurements. BMI and AHI were positively associated and were both positively associated

with RBC aggregation. Analyses of covariance and multiple regression analyses revealed that BMI was more predictive of RBC aggregation than AHI. No association of BMI classes and AHI classes with RBC deformability or blood viscosity was observed. This study shows that increased RBC aggregation in sleep apnea patients is caused by overweight. Therapies to improve blood rheology in sleep apnea patients, and therefore reduce the risk for cardiovascular disorders, should focus on weight-loss. **S.Sinnapah *et al.***,⁵⁶.

Literature on correlation of hemoglobin with BMI

Ng TP *et al.*,⁵⁷ conducted a cross-sectional study on population-based at local community in Southeast Region of Singapore; among Chinese older adults aged 55 and above (N = 2, 550); and assayed serum albumin, haemoglobin, BMI and Mini-Mental State Examination (MMSE). In multivariable analyses controlling for gender, age, education and vascular risk factors, low albumin in the bottom quintile (OR 2.04; 95% CI 1.22–3.41) and low haemoglobin in the bottom quintile (OR 1.56; 95% CI 1.00–2.47) and low BMI with chronic comorbidity (OR 1.73; 95%CI 1.02–2.95) were independently associated with poor cognitive performance (MMSE $\leq$ 23). Among cognitively intact respondents (MMSE $\geq$ 24), albumin concentration showed a significant inverse linear relationship with MMSE scores (P for trend =0.002). In this study it is shown that low albumin, low haemoglobin and low BMI (in the presence of chronic comorbidity) are independently associated with poor cognitive performance in community-living older adults.

U.V Bagni *et al.*,⁵⁸, conducted a study on school-based cross-sectional. In this study they found out the prevalence of anemia among the adolescents was 22.8% (95%CI 16.7–30.2%), higher among girls than among boys (30.9% vs. 10.9%; $p < 0.01$). The chance of developing anemia did not change with the nutritional status according BMI or BF percentage, however, overweight girls presented lower Hb levels than those who were not overweight (12.2 g/dl vs. 12.8 g/dl, $p < 0.01$). In boys this association was not observed. Sexual maturation did not change the association of Hb and anemia with overweight and excessive body fat.

Y.Shimizu *et al.*,⁵⁹ was conducted a cross-sectional study on total of 3,203 non-anemic subjects (1,191 men and 2,012 women, 30-79 years old) who were undergoing general health checkups was conducted. The results of this study shown a positive association between the hemoglobin levels and hypertension was established for both men and women. For a one SD (standard deviation) increment in hemoglobin, the multivariable odds ratio (ORs) and 95% confidence interval (CIs) for hypertension were 1.21 (95% CI: 1.05-1.40) for men and 1.25

(95% CI: 1.13-1.39) for women. We also found that a significant association was confined to the participants with a BMI of $< 25 \text{ kg/m}^2$. Among the participants with a BMI of $< 25 \text{ kg/m}^2$, the multivariable ORs and 95% CIs for hypertension of a one SD increment in hemoglobin were 1.34 (95% CI: 1.12-1.60) for men and 1.31 (95% CI: 1.16-1.47) for women. Meanwhile, among those with a BMI of $\geq 25 \text{ kg/m}^2$, the corresponding values were 1.01 (95% CI: 0.79-1.30) and 1.09 (95% CI: 0.87-1.37).

A. Anari Ghadiri *et al.*,⁶⁰ conducted cross-sectional study in Yazd to assess the relation of body mass index with hemoglobin and iron parameters among 406 adult patients 18–65 years old. Diabetes and conditions that could influence body iron stores were excluded. In this study they found that there is no difference in hemoglobin concentrations, MCV, serum iron, TIBC, transferrin saturation index, and ferritin between normal weight, overweight, and obese persons.

This was a cross sectional study conducted on 200 medical students aged 17-23 years studying at Kathmandu Medical College, Duwakot, Bhaktapur. After taking consent, anthropometry was done using standard protocol. Estimation of hemoglobin (Hb) level was done by Sahli's acid hematin method and hemoglobin was expressed in gram/deciliter (gm/dl). According to the World Health Organization (WHO), hemoglobin level $< 12 \text{ gram/deciliter}$ was considered as anemic. Results of this shown that among 200 students enrolled, 43.5%(87) of students were found to be anemic. Out of which 72.41%(63) were girls. About 46.15% of overweight students and 50% of underweight students were anemic. The correlation of haemoglobin to grades of body mass index showed a positive association of hemoglobin with body mass index among underweight and overweight boys. There was a negative association in underweight girls. But neither of the correlation showed significance to < 0.05 . Conclusion: A positive correlation of hemoglobin level with body mass index was found in boys. Anemia is more prevalent in girls which is of concern and has to be addressed. **(G. Khakurel *et al.*,**⁶¹.

V.Singh *et al.*,⁶² was conducted a study on a total 64 healthy medical student volunteers , males [45] and females [15], of aged 18 to 25 years, were participated. The analysed is done after taking consent, linear height measured by measuring tape mounted on the wall and Weight recorded by weighing machine. Data of Haemoglobin gm/dl (Sahli's Method), and BMI (Kg/m^2). The study showed that, all subjects ($n= 64$) Hemoglobin (13.26 ± 1.94), Height (1.71 ± 0.07), Weight (64.11 ± 13.24) and BMI (22.20 ± 3.98) were estimated. Correlation between Wt and Hb was $r= 0.1322$ has non-significant positive correlation. Correlation

between BMI and Hb was $r = 0.017628$ also has non-significant positive correlation. Whereas Correlation between Ht and Hb was $r = 0.316576$ has significant positive. There was significant difference between Ht ($p < 0.001$), Wt (< 0.001) and near significance was Hb ($p < 0.05$) between males and females. There was significant difference ($p < 0.05$) between mean BMI (Kg/m²) of males (22.7 ± 4.08) and females (20.4 ± 2.85).

A. Elmugabil *et al.*,⁶³, was conducted a cross-sectional study at Khartoum, Sudan. Obstetric data were collected from 388 pregnant women at mean (standard deviation) of 10.5 (3.1) weeks of gestation using questionnaires. Weight and height were determined, and BMI was calculated. There were 15 (4.4%), 95 (28.1%), 127 (37.6) and 101 (29.9%) women who were underweight, normal weight, (18.5–24.9 kg/m²), overweight (25–29.9 kg/m²) and obese (≥ 30 kg/m²), respectively. Hemoglobin levels and white blood cell counts were significantly higher in obese than non obese groups. Compared with normal BMI, overweight and obesity were associated with higher hemoglobin level. In this study it concluded that obese women had higher white blood cell count and hemoglobin level.

M. Huang *et al.*,⁶⁴ conducted study on a total of 8364 participants, aged 20–85 years and were recruited in National Health and Nutrition Examination Surveys (NHANES) 2003–2006, the model of PROC Survey Logistic regressions via using AA biomarkers in blood, hemoglobin adducts of acrylamide and glycidamide (Hb AA and Hb GA), as the measure of internal exposure to AA, and assessing obesity, abdominal obesity and overweight with body mass index (BMI) or waist circumference (WC). After the adjustment of sociodemographic variables, lifestyle behaviors, and health-related factors, the ratio of Hb GA to Hb AA (Hb GA/Hb AA) was significantly associated with obesity (p for trend < 0.0001). The odd ratios (ORs) with 95% confidence intervals (CIs) of Hb GA/Hb AA across increasing quartiles were 1.740 (1.413–2.144), 2.604 (2.157–3.144), and 2.863 (2.425–3.380) compared with the lowest quartile. Hb GA was positively associated with obesity [OR (95% CI): 1.226 (1.041–1.443), 1.283 (1.121–1.468), and 1.398 (1.165–1.679); p for trend = 0.0004], while Hb AA was inversely associated with obesity [OR (95% CI): 0.839 (0.718–0.980), 0.713 (0.600–0.848), and 0.671 (0.554–0.811); p for trend < 0.0001]. Negative associations were found between the sum of Hb AA and Hb GA (Hb AA + Hb GA) and the body weight outcomes.

S. Acharya *et al.*,⁶⁵ was conducted a study on total of 232 female undergraduate students were participated in the study. Among the sample, 34.6% was anemic when we considered 12 g/dl as the cutoff value. In this study they found significant negative correlation between blood Hb

and body fat percentage. Correlation between Hb and weight and height and BMI showed lower correlation than the body fat percentage. Hence, increase in body fat may be considered as an indicator of lower Hb level.

SM Eljamay *et al.*,⁶⁶, was conducted this study to find there relationship between body mass index (BMI) and anemia (Hb %). Data were collected from polyclinic Dar Esalam Centre, privet clinic Elrasheed laboratory, Elhrash polyclinic in Derna City \ Libya, the period of collection data was from May 2019 to May 2020. 360 samples were collected from different ages starting from 5 to 75 years and from different weights starting from 10 to 130 kilograms. From weights and lengths were also measured and then BMI was calculated by the metric, BMI formula = Weight (KG) ÷ Height (Metres²). For each case was collected (2ml) of venous blood were withdrawn by sterile vain puncture and divided as in EDTA tube to analyse the samples by BC-3200 Auto Hematology Analyzer. Statistical analysis by (statistical package for social science spss) SPSS for windows, version 26; was used for data analysis. Values were expressed as Frequency, Percent %, means ± SD and Chi-square test. Correlation between variables was assessed. The study concluded that there is no relationship between BMI & anemia if their relation between them was by chance, the relationship was between BMI & Gender by $\chi^2=837$, P-Value= 360> 1.

SECTION VI

Literature on correlation of Erythrocytes sedimentation rates with BMI

E.D. Kantor *et al.*,⁶⁷, conducted a study on Adolescent body mass index and erythrocyte sedimentation rate in relation to colorectal cancer risk. Compared with normal weight (BMI 18.5 to <25 kg/m²) in late adolescence, upper overweight (BMI 27.5 to <30 kg/m²) was associated with a 2.08-fold higher risk of CRC (95% CI 1.40 to 3.07) and obesity (BMI 30+ kg/m²) was associated with a 2.38-fold higher risk of CRC (95% CI 1.51 to 3.76) (p-trend: <0.001). Male adolescents with ESR (15+ mm/h) had a 63% higher risk of CRC (HR 1.63; 95% CI 1.08 to 2.45) than those with low ESR (<10 mm/h) (p-trend: 0.006). Associations did not significantly differ by anatomic site.

MD George *et al.*,⁶⁸ was conducted a cross sectional study on Impact of obesity and adiposity on inflammatory markers in patients with rheumatoid arthritis and the method used for Body Composition cohort (n = 451), including whole-body dual x-ray absorptiometry measures of fat mass index; and the longitudinal Veterans Affairs Rheumatoid Arthritis (VARA) registry

(n = 1,652), they found that obesity is associated with higher CRP levels and ESR in women with RA. This association is related to fat mass and not RA disease activity. Low BMI is associated with higher CRP levels in men with RA.

The retrospective case conducted by **W.V Probasco *et al.***,⁶⁹ on the Prevalence of idiopathically elevated ESR and CRP in patients undergoing primary total knee arthroplasty as a function of body mass index. Eligible patients (n = 181) were stratified by BMI category. Elevated ESR was associated significantly with BMI (ESR: $r^2 = 0.89$, $P < 0.001$) unlike elevated CRP ($r^2 = 0.82$, $P = 0.133$) and WBC count ($r^2 = .01$; $P = .626$). No statistically significant differences in ESR values and WBC count between the “healthy patients” versus “patients with comorbidities” were demonstrated within any BMI category. In patients of normal weight (BMI 20–25 kg/m²), “healthy patients” had a statistically significantly higher mean CRP level than “patients with comorbidities” (1.73 mg/L vs. 0.70 mg/L, $P < 0.001$). There were no other statistically significant differences in mean CRP levels by health status.

A. Sharma *et al.*,⁷⁰ conducted a cross sectional study on the impact of obesity on inflammatory markers used in the assessment of disease activity in rheumatoid arthritis, in this study the results shown that obese patients with RA (n = 85) had higher CRP and ESR than non-obese patients (n = 66) (p-values 0.008 and 0.000005, respectively). In addition, obese females with RA had significantly higher CRP and ESR as compared to non-obese females. However, the difference was not significant in males. Twenty-one obese (24.7%) and two non-obese RA patients (3%) had elevated CRP (difference of approximately 22% . Forty obese (47%) and 16 non-obese RA patients (24.2%) had elevated ESR (difference of approximately 23%. Thus, obesity was the attributable cause of falsely elevated CRP and ESR in 22% and 23% of patients, respectively, they concluded that about one-fifth of patients with RA, who are actually in low disease activity, may have elevated inflammatory markers, primarily because of obesity. Therefore, elevated CRP and ESR in obese patients with RA should be interpreted with caution because it may lead to unnecessary overtreatment.

E. Cohen *et al.*,⁷¹ conducted a Cross-sectional analysis on 7526 men and 3219 women. White blood cell count (WBC); platelet (PLT) count; erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP) were assessed in four BMI categories: normal, overweight, obese and morbidly obese. The prevalence of each inflammatory marker increased significantly when comparing abnormal to normal BMI ($p < 0.0001$). they found that inflammatory markers are

significantly higher in subjects with abnormal compared to normal BMI. This difference was found to be greater in women than in men.

V.Alende Catro *et al.*,⁷², conducted a cross-sectional study of 1472 adults with no known inflammatory disorders (44.5% male; median age, 52 years; range, 18–91 years), randomly selected from a municipality in Spain. The participants underwent simultaneous measurements of ESR, serum CRP, and interleukin-6 concentrations. They found that in this general adult population with no overt inflammatory disease, the discordant pattern of high ESR and normal CRP was associated with greater age, whereas the pattern of high CRP and normal ESR was associated with higher BMI.

SECTION VII:

Literature on correlation of hematocrit/ Packed cell volume with BMI-

A.M. Akinnuga *et al.*,⁷³, conducted a study in several reports, packed cell volume (PCV) and body mass index (BMI) have been identified as risk factors that significantly contribute to blood pressure increase. Therefore, there is necessity to investigate the correlation between PCV and BMI in hypertensive and normotensive subjects, a total of 192 subjects of age between 19 and 70 years were examined, 79 subjects (40 males and 39 females) were hypertensive and 113 subjects (61 males and 52 females) were normotensive. In all subjects, blood pressure, body weight and height were measured via comfort automatic blood pressure monitor, weighing scale and meter rule respectively. PCV also was measured through an automated haematology analyzer. The findings of this study suggested that there was a positive correlation between BMI and PCV in hypertensive subjects (male and female) but only significant in male subjects ($r= 0.306$, $P< 0.05$) thus PCV has a significant positive linear correlation with BMI in hypertensive male subjects. Also, the linear positive correlation between PCV and BMI was not significant in both male and female normotensive subjects ($r= 0.088$ and $r= 0.0288$ respectively, $P< 0.05$) unlike in hypertensive subjects where it was only significant in male but not significant in female ($r= 0.0265$, $P< 0.05$).

The aimed of this study was to investigate the relation between the hypertension risk factors (BMI and PCV) in hypertensive and normotensive individuals, a total of 100 subjects of age ranging between 20 and 70 years from Dai Elhelal Clinic were selected, 50 subjects were hypertensive and divided (25 males and 25 females) and 50 subjects were normotensive and divided (25 males and 25 females).The final results of this study suggest that the PCV and BMI

are strong risk factors for hypertension. Therefore, future research should seek to investigate the relation between PCV and BMI and its impact as risk factors on blood pressure to reduce the incidence of hypertension and prevent the disease related to high blood pressure such as atherosclerosis, strokes and cardiovascular diseases. As soon as the main risk factors among hypertension patients are established (overweight and high PCV), the prevention of this hypertension is highly possible before any dangerous consequences.(**M.A. Ebsaim *et al.***,⁷⁴

C.Prasad *et al.*,⁷⁵, conducted a cross-sectional study to study the correlation between hematological profile and body mass index in adults, in the Department of Physiology, Govt. Medical College, Bettiah, Bihar, India, for 1 year. 200 participants, 100 males and 100 females in the age group 18 to 32 years were included, in this study PCV is statistically increased in overweight and obese individuals as compared to other BMI groups in both males and females. Total leucocyte count was significantly higher in overweight and obese subjects when compared to normal subjects. We found no change in Haemoglobin concentration and RBC count in all BMI groups. In this study they observed leucocytosis and higher PCV in overweight and obese individual groups when compared to underweight and normal weight BMI groups. There is direct positive correlation between BMI and total leucocyte count. RBC count and haemoglobin concentration shows no statistical significance among all BMI groups.

B.K. Abdulqader *et al.*,⁷⁶, conducted a cross-sectional study was done on 112 healthy individuals, aged between 18-23 years .The results of this study shown that Packed cell volume among males was higher $47.45 \pm 3.409\%$ than for females $39.90 \pm 3.169\%$, with a difference statistically significant ($p= 0.000$), also the correlation of PCV revealed direct significance with body mass index ($p= 0.011$) and indirect statistically significant with body fat percentage ($p= 0.000$). The prevalence rate of smoking was 13.4% and the level of PCV among smokers was $46.80 \pm 6.085\%$, significantly higher ($p= 0.015$) than among non-smokers $43.43 \pm 4.702\%$.

E.I. Obeagu *et al.*;(202)⁷⁷; conducted a hospital based cross-sectional study among obese individuals and non-obese individuals at Omisanjana area of Ado Ekiti, Eighty (80) obese individuals based on age groups. The results above show no significant difference in PCV ($p=0.241$), WBC ($p=0.445$), LYM ($p=0.531$), GRAN ($p=0.514$), MID ($p=0.930$), LYM ($p=0.984$), GRAN ($p=0.682$), MID ($p=0.343$), RBC ($p=0.971$), HGB, MCV ($p=0.389$), MCH ($p=0.755$), MCHC ($p=0.052$), RDW_CV ($p=0.392$), RDW_SD ($p=0.177$), PLT ($p=0.055$), MPV ($p=0.224$), PDW ($p=0.432$), P_LCR ($p=0.096$) when compared between obese individuals and nonobese individuals based on age group respectively. This study revealed no

changes in the hematological parameters studied. It shows that age variations in obesity has no significant impact on the hematological parameters of the affected individuals.

SECTION VIII:

Literature on correlation of Platelet with BMI

E.R. Coban *et al.*,⁷⁸, this study was designed to evaluate MPV in patients with obesity compared with non-obese control subjects. Mean platelet volume (MPV), a determinant of platelet function, is a newly emerging risk factor for atherothrombosis. We selected 100 non-obese subjects and 100 subjects with obesity (BMI) ≥ 30 kg/m² matched for age and gender. The MPV was significantly higher in obese group than in non-obese control group (10.3 ± 1.2 vs. 9.0 ± 0.8 fl, $p < 0.01$). MPV was positively correlated with BMI in obese group ($p < 0.05$). Increased MPV may be a possible cause for increased cardiovascular risk in patients with obesity.

The objective was to evaluate the effect of weight loss on the MPV in obese patients. From selected 30 obese women patients and 30 non-obese healthy women subjects. All obese patients took the same content and caloric diet treatment for 3 months. Body mass index (BMI), metabolic parameters and MPV were measured at baseline and after 3 months diet treatment. Before diet treatment, obese group had significantly higher MPV levels than in the non-obese control group (8.18 ± 1.09 fl vs. 8.01 ± 0.95 fl, $p = 0.004$). MPV showed positive correlations with BMI level in the obese group ($r = 0.43$, $p = 0.017$). BMI significantly decreased after diet treatment (36.2 ± 3.2 kg/m² vs. 34.7 ± 3.6 kg/m², $p < 0.001$), in the obese group. MPV significantly decreased after diet treatment in the obese group (8.18 ± 1.09 fl vs. 8.08 ± 1.02 fl, $p = 0.013$). There was a positive correlation between weight loss and reduction in MPV ($r = 0.41$, $p = 0.024$). In addition to its well-known positive effects on cardiovascular disease risk, weight loss may also possess significant anti-platelet activation properties that can contribute its antiatherogenic effects in obese patients.**E Coban *et al.*,⁷⁹**

D. Samocha Bonet *et al.*,⁸⁰, was conducted a study on correlation between platelet count, platelet activation, and systemic inflammation in overweight, obese, and morbidly obese individuals. A total of 6319 individuals participated in the study. Platelet activation markers were studied among 30 obese (BMI = 41 ± 8 kg/m²) and 35 non obese (BMI = 24 ± 3 kg/m²) individuals. Platelet activation status was evaluated by flow cytometry using specific antibodies against the activated platelet membrane glycoprotein IIb/IIIa, p-selectin (CD-62 p),

and binding of Annexin-V to platelet anionic phospholipids. The results of this study shown that overweight, obese, and morbidly obese females had significantly elevated platelet counts ($P < .0001$) compared with normal-weight females. No significant elevation of platelet counts was observed in the male subgroups. A significant age adjusted correlation between BMI and platelet counts ($P < .0001$) was found among females. This correlation was attenuated ($P = .001$) after adjustment for hs-CRP concentrations. The flow cytometry analysis of platelets showed no significant differences in activation marker expression between non obese and obese individuals. Obesity may be associated with elevated platelet counts in females with chronic inflammation. Obesity is not associated with increased platelet activation.

A Furman- Niedziejko, *et al.*,⁸¹, aimed of this study was to evaluate the relationship between platelet indices, including mean platelet volume, and abdominal obesity in patients with metabolic syndrome. 382 consecutive patients were enrolled in the study and divided into three groups: group A, 218 patients with metabolic syndrome and abdominal obesity (132 M, mean age 65.3 ± 10.9 yrs); group B, 35 patients with metabolic syndrome without abdominal obesity (28 M, mean age 63.3 ± 11.2 yrs); and, group C, 129 patients without metabolic syndrome and without abdominal obesity (99 M, mean age 62.2 ± 13.8 yrs). The findings of this study shown that, in group A, mean platelet volume was significantly higher than in group C (10.70 ± 1.01 vs. 10.35 ± 0.94 fL, $p = 0.007$). However, there was no difference in mean platelet volume between group A and B (10.70 ± 1.01 vs. 10.63 ± 1.03 fL, $p > 0.05$). Furthermore, in group A, mean platelet volume was correlated with waist circumference ($r = 0.14$, $p = 0.041$) and body mass index ($r = 0.14$, $p = 0.045$). In all study groups, a significant association between mean platelet volume and platelet count ($r = -0.33$, $p < 0.001$) was found.

The study conducted by **M. Puccini; *et al.*,⁸²**, a total of 64 patients were included in which 35.9% were patients with normal weight. A higher ADP- and TRAP-dependent platelet reactivity was observed in overweight and obese patients (ADP: median 27 units (U) [IQR 13–39.5] vs. 7 U [6–15], $p < 0.001$ and TRAP: 97 U [73–118.5] vs. 85 U [36–103], $p = 0.035$). Significant positive correlations were observed between agonist-induced platelet reactivity and BMI. Despite the use of DAPT, a higher platelet reactivity was found in overweight and obese patients with CCS. If these patients will benefit from treatment with more potent platelet inhibitors, it needs to be evaluated in future clinical trials.

CHAPTER-4

RESEARCH METHODOLOGY

4.1) Research Approach

Comparative study research approach was used.

4.2) Research Design

This study is a cross-sectional design, collecting data at specific point in time.

The study was carried out in blood sample collected from student of RIPANS and tests were performed in haematology laboratory of MLS Department, RIPANS.

4.3) Population

The population of the study will comprise of different sex. A total of 200 samples will be taken from healthy individuals for study, 100 samples from boys and 100 samples from girls , RIPANS.

4.4) Sample

The study selected fresh samples from boys and girls of underweight and overweight, who meets the specified inclusion criteria.

4.4.1 Inclusion criteria:

1. Candidate of age group between 18-45 years both gender.
2. Candidate whose body mass index is below normal (<18.4) and above normal (>25.0).

4.4.2 Exclusion criteria:

1. Candidate who have disorders known to affect body mass index such as hypothyroidism, depression, diabetes, heart failure and polycystic ovary syndrome

4.5) Sampling technique

The morning blood sample collected under aseptic precaution 2 ml blood sample taken from ante cubital vein and then transferred to EDTA tube /vials from both male and female individuals of RIPANS students, then these samples were processed using manual method in the department of haematology laboratory, RIPANS.

Using a weighing machine, the subject's weight was determined in kilograms (kg). The subject's height was measured in meters without shoes on. Weight in kilograms divided by height in meters squared (kg/m^2) yielded the BMI.

4.6) TOOLS AND TECHNIQUES

The study employs structured questionnaires for data collection and willing to participate provide their consent after receiving comprehensive information about the study, alongside various manual methods for determining hematological parameters. Body mass index checking instruments are utilized to categorize participants into underweight and overweight groups. These tools enable comprehensive investigation into the relationship between body mass index and hematological parameters.

4.6.1) Laboratory Analysis

The collected samples were brought to the laboratory and analyzed using manual methods. The methods used for each parameter are as follows

- **Method of blood collection**

- Blood may be described as a specialized connective tissue, which circulates in a closed system of blood vessels. Blood collection is a routine medical procedure used to obtain blood samples for diagnostic testing. It is performed by the trained professionals using sterile techniques to ensure patient safety and accurate results.

Performing the venipuncture: The venipuncture procedure is to obtain quality blood specimens upon which the laboratory can perform testing. And the venous blood is preferred for most of the hematological examination.

Materials requirement:

- Disposable syringes and needles
- Tourniquet
- Gauze pads or adsorbent cotton
- 70% alcohol or spirit and EDTA vial

Procedure:

- a) Select the prominent vein for the most venipuncture, and the median cubital vein is the one used for the patient, if this vein is unsuccessful, one of the cephalic or basilic veins may be used.
- b) Apply the tourniquet 3-4 inches above the venipuncture area.
- c) Once the vein to be used has been located, cleanse the area thoroughly with spirit to prevent any contamination by making a smooth circular pass moving in and outward.
- d) Allow the skin dry and do not touched the skin after it has been cleansed. Perform the venipuncture.

- **Determination of blood hemoglobin by cyanmethemoglobin method**

Principle:- when blood is mixed with Drabkin's reagent containing potassium cyanide and potassium ferrocyanide, hemoglobin reacts with ferricyanide to form methemoglobin which is converted to stable cyanmethemoglobin (HiCN) by the cyanide. The intensity of the colour is proportional to hemoglobin concentration in blood and it is compared with a known cyanmethemoglobin standard at 540 nm (green filter).

- Procedure:-

- a) Pipette in the tubes 5ml of drabkin's reagent and 0.02 ml of blood which labeled as 'test'.
- b) Mix the contents in the tube labelled as 'test' thoroughly and wait for 5 minutes.
- c) Read absorbance of 'test' by setting blank to 100% T at 540.
- d) Read absorbance of standard (15 g/dl) by pipetting it in a cuvette.

- Calculations:-

Hemoglobin, g/dl = $\frac{\text{O.D. TEST} \times 15}{\text{O.D. STD}}$

O.D. STD

- **Total erythrocyte count by hemocytometer-**

- Principle:- The blood specimen is diluted 1:200 with the RBC diluting fluid and cells are counted under high power by using a counting chamber. The number of cells in undiluted blood are calculated and reported as the number of red cells μl of whole blood.

- Procedure:-

- a) Mix the anticoagulated blood carefully by swirling the bulb.
- b) Draw blood upto 0.5 mark.
- c) Carefully wipe the excess blood outside the pipette by using cotton or a gauze.
- d) The pipette is rotated rapidly by keeping it horizontal during mixing.
- e) After 5 minutes, by discarding few drops from the pipette and holding it slightly inclined small volume of the fluid is introduced under the cover slip which is placed on the counting chamber.
- f) Allow the cells to settle for 2-3 minutes.
- g) Place the counting chamber on the stage of microscope and switch to low power objectives. Adjust light and locate the large square in the center with 25 small squares.
- h) Now switch to high power objectives and the red blood cells in the four corner squares and in the center square in the diagram are counted.
- i) Use following formulae for the calculation

Total red blood cell per litre of blood = number of red cells counted x 10,000

Or

- 1) Red cell count (per liter) = No. of cells counted/Volume counted X Dilution X 10⁶
- 2) Total red blood cells / cu mm = No. of red cells counted X Dilution / Area counted X Depth of fluid.

Where,

- a) dilution = 1:200 (i.e., 200)
- b) Area counted = $80/400 = 1/5$ sq.mm
- c) Depth of fluid = $1/10$ mm
- d) No. of red cell counted= N

$$\begin{aligned}
 \text{Hence total RBC count} &= N \times 200 / (1/5 \times 1/10) \\
 &= N \times 2000 \times 50 \\
 &= N \times 10,000
 \end{aligned}$$

- Normal range:

Male: $4.5 \text{ to } 6.0 \times 10^6$ Cells/cu mm

Female: $4.0 \text{ to } 4.5 \times 10^6$ Cells/cu mm

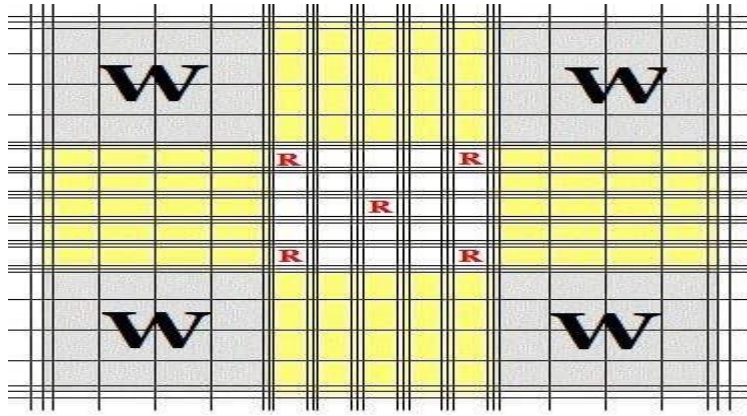


Figure 4.1: The 'R' is the site where Red cell is counted.

● Total leucocyte count by hemocytometer

- Principle:- The glacial acetic acid lyses the red cells while the gentian violet slightly stains the nuclei of the leucocytes. The blood specimen is diluted 1:20 in a WBC pipette with the diluting fluid and the cells are counted under low power of the microscope by using a counting chamber.
- Procedure:-
 - a) Draw blood up to 0.5 mark of a WBC pipette.
 - b) Carefully ,wipe excess blood outside the pipette by using cotton. Draw diluting fluid up to 11 mark.
 - c) Mix the contents in the pipette and after 5 minutes by discarding few drops, fill the counting chamber and allow the cells to settle for two to three minutes.
 - d) Focus on one of the W mark area by turning the objective to low power and then count cells in all four marked corner.
 - e) Calculation:-

No. of white cells/cu mm = No. of cells counted x Dilution/ Areas counted
x Depth of fluid

Where, (1) Dilution = 20

(2) Area counted = $4 \times 1 \text{ sq.mm} = 4 \text{ sq.mm}$

(3) Depth of fluid = 0.1 mm

Hence,

Number of WBC/ cu mm of whole blood = No. of cells counted X $\frac{20}{4 \times 0.1}$

= No. of cells counted X 50

- Normal range: 4000-10,000/cu mm

● **Determination of Platelet count hemocytometer -:**

- Principle –

The blood specimen is diluted 1:200 with the platelet diluting fluid in RBC pipette and cells are counted under high power (40x objective) by using a counting chamber. The number of cells in undiluted blood are calculated and reported as the number of platelet per cu mm of whole blood.

Procedure –

- a) Mix the blood specimen carefully and by using RBC pipette draw blood up to 0.5 mark.
- b) Wipe excess blood outside the pipette by cotton or a gauze.
- c) The diluting fluid is drawn up to 101 mark (1:200 dilution). Mix the contents in the bulb thoroughly.
- d) After 5 minutes, discard the first drop, then transfer a small drop on one side of the counting chamber.
- e) Place the filled mounted counting chamber under petri dish with a moist filter paper. Let it stay undisturbed for 15 minutes to let the platelet settle and prevent evaporation of diluting fluid.
- f) Place the counting chamber carefully on the stage of microscope. Under low power objective (10x) focus on RBC counting area. Move to view the corner square of the red cell area and change to high power objective.
- g) Keep the condenser down and reduce the light by adjusting the diaphragm. The platelets will appear like highly refractile particles.

h) Count platelets in all 25 small squares. The area covered by 25 squares is equivalent to 1 sq.mm.

i) Calculations –

Platelets per cu mm = No. of platelets counted x Dilution/Volume of fluid.

Where,

1) Dilution = 200

2) Volume of fluid = $1 \times 0.1 = 0.1$ cu mm

3) Platelets per cu mm = No. of platelets x $200/0.1$
= No. of platelets x 2000

- Normal range: 250,000- 500,000/cu mm

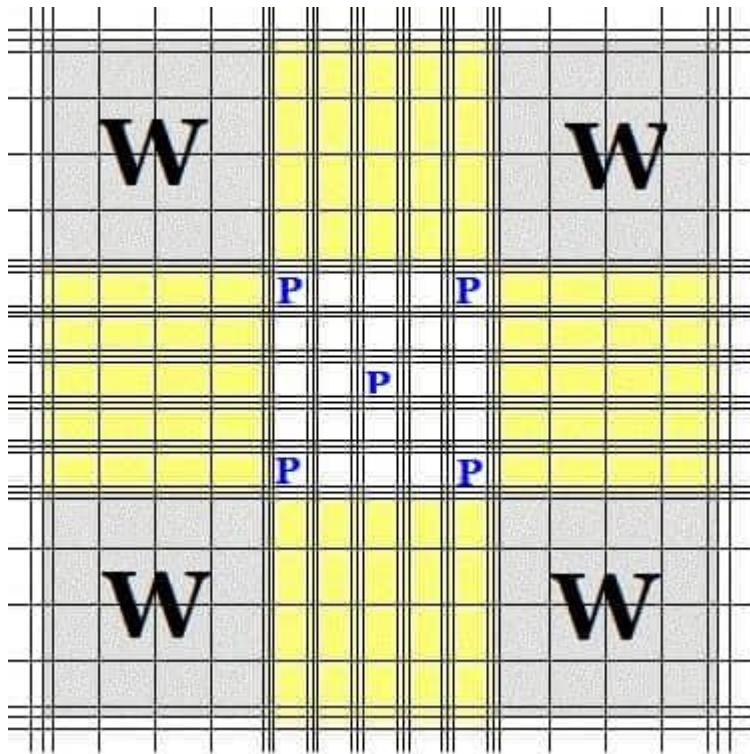


Figure 4.2: The 'W' is the site where Platelet is counted

● Differential Leucocyte Count:-

Principle:- The polychromatic staining contain methylene blue and eosin dyes. These dyes induce multicolour when applied to cells. Methanol acts as fixative and a solvent which does not allow any further change in the cells and makes them adhere to the glass

slides. The basic component of white cells is stained by acidic dye (eosin) and the acidic components takes blue to purple shades by basic dye(methylene blue).

Procedure :-

- a) A thin smear is prepared by spreading a small drop of blood evenly on a slide and then air dried the blood smear.
- b) Cover the smear with the staining solution by adding 10 drops on the smear and wait for 2-3 minutes.
- c) Add twice numbers of the drops of buffer solution and mix the reaction mixture adequately by blowing on it through pipette, wait for 10 minutes.
- d) Wash the smear using tap water and stand the slide on the laboratory counter dry.
- e) First examine the stained smear under the low power and choose the portion slightly before the tail- end where the red cells are,beginning to overlap.
- f) Place a drop of immersion oil on the smear and switch to the immersion objective, and increase the light by opening the iris diaphragm.
- g) Examine the film by moving from one field to the next systematically. Record the type of leukocytes seen in each field
- h) Count at least a total of 100 leukocytes.

Normal value:- (male or female)

- Neutrophils : 40-75%
- Lymphocytes : 20-45%
- Monocytes : 2-8%
- Eosinophils : 1-4%
- Basophils : 0-1%

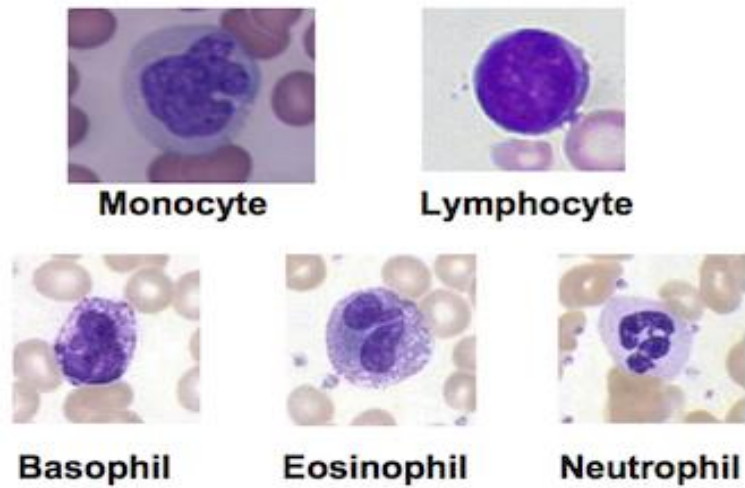


Figure.4.3. Different types of white blood cells

● **Determination of Red cell indices:-**

Mean Corpuscular Volume, Mean Corpuscular Hemoglobin, and Mean Corpuscular Hemoglobin Concentration-

a) Mean Corpuscular Volume(MCV):

$$\text{MCV} = \frac{\text{PCV} \times 10}{\text{Red cells counted in millions}}$$

- Normal range: 82 to 92 fl

b) Mean Corpuscular Haemoglobin (MCH):

$$\text{MCH} = \frac{\text{haemoglobin concentration} \times 10}{\text{RBC Count in million}}$$

- Normal range: 27- 32 pg

c) Mean Corpuscular Hemoglobin Concentration (MCHC)

$$\text{MCHC} = \frac{\text{haemoglobin} \times 100}{\text{PCV}}$$

PCV

- Normal range: 32- 36%

● **Determination of Erythrocytes Sedimentation Rate by wintrobe method**

ESR is increased in all conditions where there is a tissue breakdown or where there is entry of foreign proteins in the blood. The determination is useful to check the progress of the disease. If the patient is improving the ESR tends to fall and if the patient condition is getting worse the ESR tends to rise.

Procedure :-

- a) Mix the blood carefully.
- b) Fill the wintrobe tube to the zero mark by using a syringe.
- c) Place the tube in exact vertical position in the stand, and set the timer for one hour.
- d) At the end of one hour note the level of erythrocyte column in terms of mm after one hour

Normal range:

- Male: 0-9 mm/after 1 hour
- Female: 0-20 mm/after 1 hour

● **Determination of Hematocrit (PCV)**

Principle:- when anticoagulated blood is centrifuged in a hematocrit tube at high speed, the erythrocytes sediment at the bottom. The red cell column is called packed cell volume.

Procedure:

- a) Mix the blood carefully and label a Wintrobe tube.

- b) Fill the tube by using Pasteur pipette or a syringe up to the 100 mark. Avoid trapping of air bubbles.
- c) Place the tube in a centrifuge cup and use another wintrobe tube to fill the opposite cup .
- d) Centrifuge for 30 minutes at 3000 rpm.
- e) Note the reading of hematocrit .
 - Normal values
 - Male- 42 to 52%
 - Female -36 to 48%

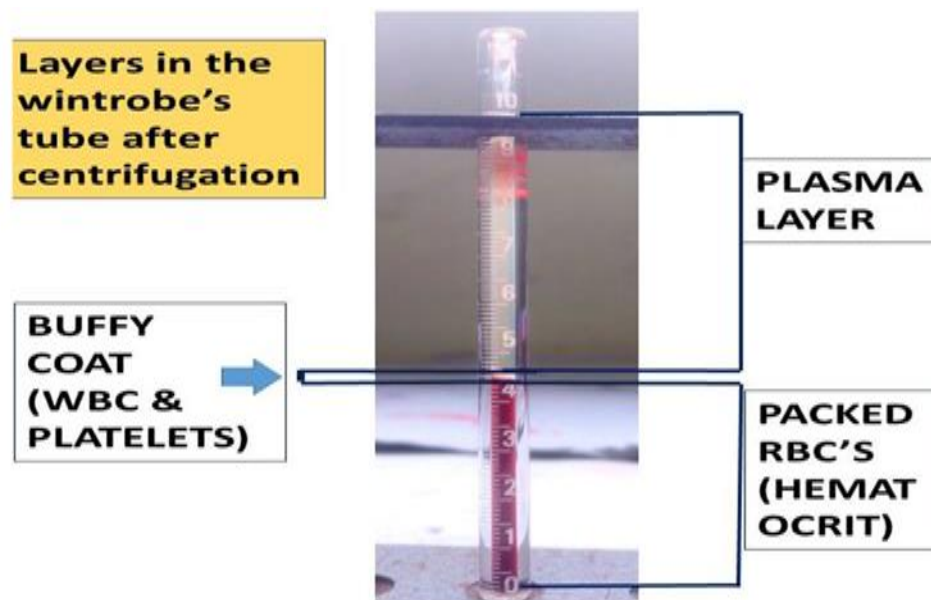


Figure.4.4. Wintrobe tube

● **Calculate the Body mass index :**

- At an individual level, BMI can be used as a screening tool.
- Weight that is higher than what is considered as a healthy weight for a given height is described as overweight or obese. Weight that is lower than what is considered as healthy for a given height is described as underweight.
- Normal BMI range = 18.5- 24.9 kg/m²

Procedure:

- a) Take the height measurement ask your client to remove their shoes prior to taking the measurement
- b) Ask your client to stand with their back to the wall and look directly forward. The back of their feet, calves, bottom, upper back and the back of their head should all be in contact with the wall, and flooring that is not carpeted and against a flat surface. Make sure legs are straight, arms are at sides, and shoulders are level.
- c) Taking weight measurements to ensure you take reliable measurements using body weight scales you must: Zero the scales before the client steps onto them
- d) Ask the client to remove any 'heavy' items from their pockets (key's, wallets etc) and remove any heavy items of clothing or apparel (big jackets, shoes, woollen jerseys etc), and ask client to look straight ahead and stay still on the scales. Wait for the needle/digital screen to settle before recording the measuring.

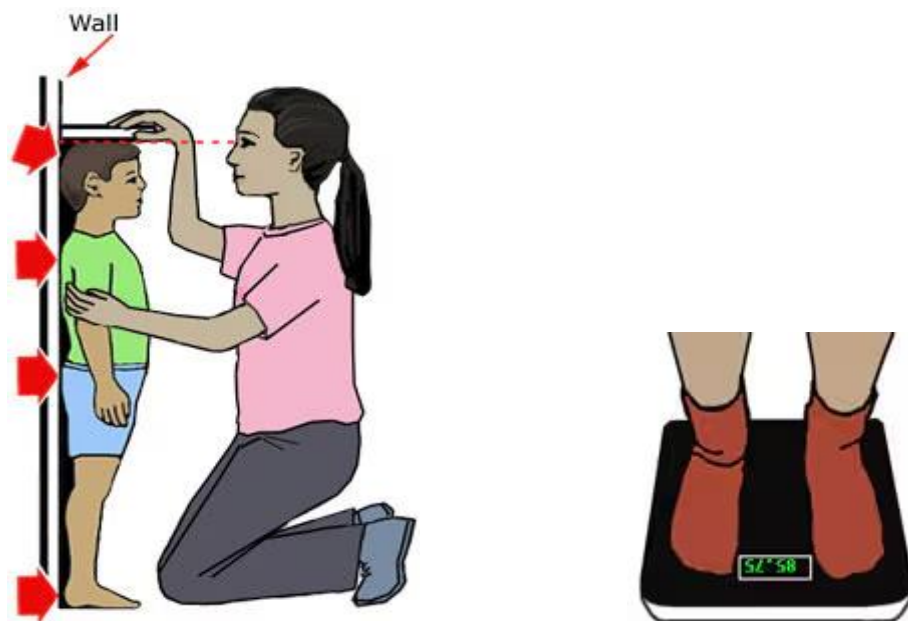


Figure .4.5. Measuring of body mass index

4.7. PLAN FOR DATA ANALYSIS

The data collected was entered into a Microsoft Excel Worksheet, presented through table and chart. Mean values along with their corresponding, standard deviations (SD) were calculated, independent sample t- test was used to compare mean values between two groups, in Statistical Package for the Social Sciences (SPSS) software, with a significance level set at $p < 0.05$ (the p-value, or probability value indicates the likelihood of obtaining the observed results if the null hypothesis is true). All reported p-values are based on that t-test. A level of $p = 0.05$ was considered statistically significant.

The interpretation of the p-value is as follows

- $P > 0.05$ - not significant,
- $P < 0.05$ - significant and
- $P < 0.01$ -highly significant

CHAPTER-5

RESULT

This chapter comprises the results and observational from the study based on the objectives and hypothesis and can be classified as

5.1. Observation based on comparison of hematological parameters between underweight and overweight:-

- The hematological parameters such as Hemoglobin, Total leukocyte count, Platelet count, eosinophil and PCV were significantly different between underweight and overweight individuals. However RBC count, DLC(Neutrophil, Leucocyte, Monocyte, Basophil), ESR, MCV, MCH, and MCHC did not show significant differences between the two groups.

5.2. In gender-wise comparison:

1) The comparison of hematological parameters in male and female of underweight, Haemoglobin, RBC count, Monocyte, Eosinophil, PCV and ESR were significantly different between underweight males and females and Total leukocyte count, Platelet count, DLC(Neutrophil, Lymphocyte, Basophil), MCV, MCH, and MCHC did not show significant differences between underweight males and females.

2) The comparison of hematological parameters in male and female of overweight, the hematological parameters such as Hemoglobin, RBC count, DLC(monocyte, eosinophil) ,

PCV, and ESR show statistically significant differences between overweight males and females. And Total leucocyte count, platelet count, DLC(neutrophil , lymphocyte , basophil),MCV, MCH, and MCHC do not show statistically significant differences between the two groups.

3) The comparison of hematological parameters between underweight and overweight female, Hemoglobin, RBC count, platelet count, and PCV show statistically significant differences between underweight and overweight females. And Total leucocyte count, DLC(neutrophil, lymphocyte, monocyte, eosinophil basophil), MCV, MCH, MCHC and ESR do not show statistically significant differences between the two groups.

4) The comparison of hematological parameters between underweight and overweight male the Hemoglobin, platelet count, and PCV show statistically significant differences between underweight and overweight males. Overweight males tend to have higher hemoglobin levels, platelet counts, and PCV values. The Total leucocyte count, RBC count, DLC(monocyte , eosinophil , basophil) , MCV, MCH, and MCHC do not show statistically significant differences between the groups.

ESR also does not differ significantly between underweight and overweight males, indicating that the inflammatory response, as measured by ESR, is similar across both groups.

5.1: DEMONSTRATION OF DEMOGRAPHIC VARIABLES OF THE STUDY PARTICIPANTS:-

	VARIABLES	No. of participants (%)	No. of Underweight (%)	No. of Overweight (%)
AGE	18- 22 years.	32% (n=63)	60% (n=38)	39% (n=25)
	23 -27 years.	68 % (n=137)	45% (n=62)	54% (n=75)
GROUP				

	TOTAL=	200	100	95
GENDER	MALE	50% (n=100)	50% (n=50)	50% (n=50)
	FEMALE	50% (n=100)	50% (n=50)	50% (n=50)
	TOTAL	200	100	100

Table 5.1. Distribution of demographic variables of participants.

This section demonstrates the demographic information of the subjects who participate in the study on” correlation of hematological parameters with the body mass among the students of RIPANS”.

The above table shows the distribution of variables of participants in the study and and can be described as following:-

According to the data the age wise distribution of participants were categorized into two groups, i.e.18-22 yrs. and 23-27 yrs. Approximately, about 32% (n=63) of the participants were belonged to the age group of (18-22 yrs.), out of which about 60% (n=33) were in the underweight group and 39% (n=25) were in the overweight group. And also the remaining participants about 68% (n=137) belonged to the age group of (23-27 yrs.), out of which 45% (n= 62) were in the underweight group and 54% (n=75) were in the overweight group.

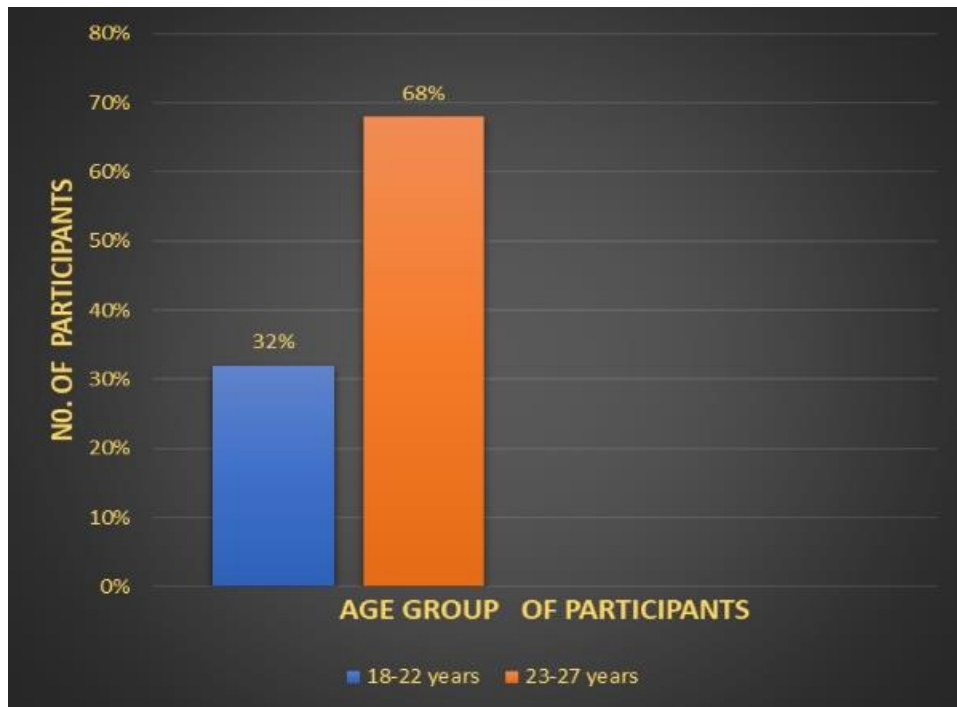


Figure 5.1. Age- wise distribution of total participants in the study

Based on gender- wise distribution, out of 200 of total participants, the 50% (n=100) were males and 50% (n=100) were females. Among the male participants, 25% (n=50) were belonged to underweight group and the 25% (n=50) were belonged to overweight group. And in the female group, about 25% (n=50) belonged to the underweight group and the remaining 25% (n=50) belonged to the overweight group.

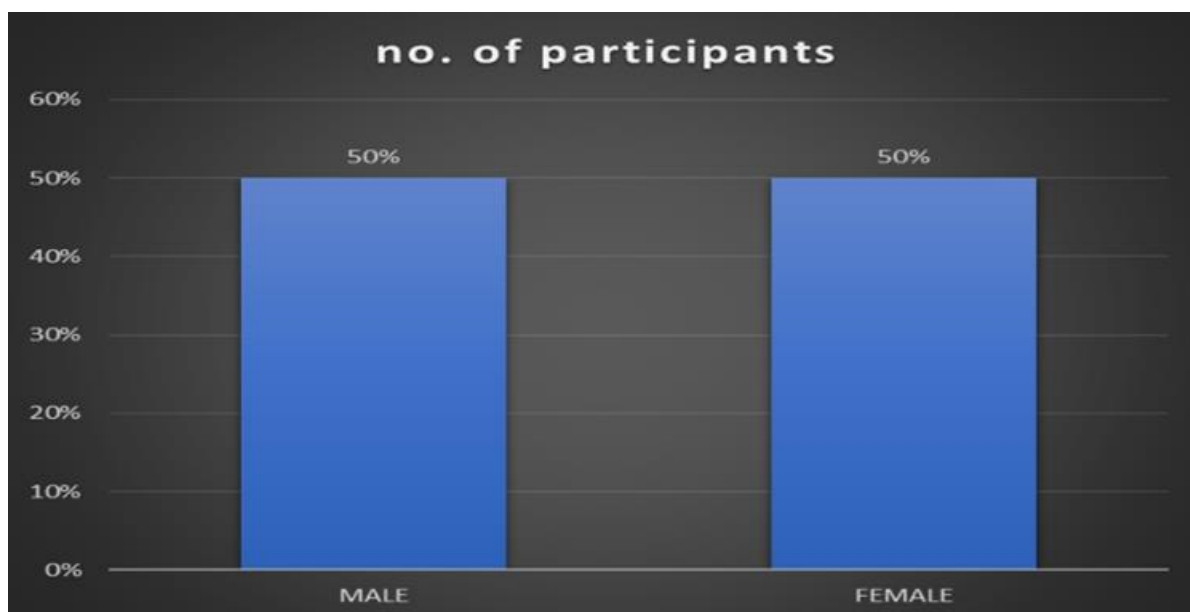


Figure 5.2. Distribution of gender in percentage

PARAMETRS	UNDERWEIGHT	OVERWEIGHT	P- Value
	(n=100)	(n=100)	
	(mean± SD)	(Mean ± SD)	

Hemoglobin (g/dl)	12.6± 1.89	13.9±1.94	0.00 <0.05
Total leukocyte Count (10 ³ /cu mm)	5606.3± 1841.6	6302.2± 1865.7	0.00 <0.05
RBC Count (million/cu mm)	4.4± 2.91	4.6± .66	0.71 >0.05
Platelet Count (lakhs/cu mm)	2.51± 7.03	3.02± 9.63	0.00 <0.05
Neutrophil (%)	55.7± 7.4	56.8± 6.2	0.25>0.05
Lymphocyte (%)	35.1± 5.07	36.4± 4.72	0.07 >0.05
Monocyte (%)	3.19± 1.8	3.4± 2.0	0.32 >0.05
Eosinophil (%)	1.67± 1.3	2.1± 1.6	0.02<0.05
Basophil (%)	.05± .21	.03± .17	0.56>0.05
PCV/Hematocrit (%)	37.8± 5.63	41.4± 6.01	0.00 <0.05
MCV (fl)	89.2± 6.03	89.8± 2.18	0.30 >0.05
MCH (pg)	30.0± .95	30.1± .78	0.40>0.05
MCHC (%)	33.5± 1.03	33.5± .49	0.78>0.05
ESR (mm/hr.)	8.13± 6.4	8.65± 7.15	0.59>0.05

Table.5.2. Comparison of hematological parameters between underweight and overweight.

Interpretation:

Table.5.2. shows the distribution of hematological parameters in underweight and overweight, data were represented as Mean± S.D, and were considered statistically significant when the P-value is less than 0.05 (5% level of significance), and can be explained as follows:-

- a) Haemoglobin - The mean value of Hb is lower in underweight i.e. 12.6± 1.89 than in overweight i.e. 13.9± 1.94, and there is highly significant with p value of 0.00(p<0.05).
- b) Total Leucocyte Count- The mean value of total leucocyte count is lower in underweight i.e. 5606.3± 1841.6 than overweight i.e. 6302.2± 1865.7 and there is no statistically significant difference observed in two groups. (p>0.05)

- c) Red blood cell count – The mean value of RBC count in underweight count is lower i.e. 4.4 ± 2.91 than overweight i.e. $4.6 \pm .66$ and there is no statistically significance difference observed in two group.($p > 0.05$)
- d) Platelet Count (lakhs/cu mm)- The mean value of platelet count in underweight i.e. 2.51 ± 7.03 is lower than the overweight i.e. 3.02 ± 9.63 and is significant at p value of 0.00($p < 0.005$)
- e) Differential leucocyte count
- i. Neutrophil (%)- The mean value of neutrophil in underweight i.e. 55.7 ± 7.4 is lower than overweight i.e. 56.8 ± 6.2 and there is no statistically significance difference observed in two group.($p > 0.05$)
 - ii. Lymphocyte (%)- The mean value of lymphocyte in underweight i.e. 35.1 ± 5.07 is lower than overweight i.e. 36.4 ± 4.72 , and there is no statistically significance difference observed in two group.($p > 0.05$).
 - iii. Monocyte (%)- The mean value of monocyte i.e. 3.19 ± 1.8 is lower than overweight i.e. 3.4 ± 2.0 , and there is no statistically significance difference observed in two group.($p > 0.05$).
 - iv. Eosinophil (%)-The mean value of eosinophil in underweight i.e. 1.67 ± 1.3 is lower than overweight 2.1 ± 1.6 , and there is highly statistically significant.($p > 0.05$).
 - v. Basophil (%)- The mean value of of basophil in underweight which is $.05 \pm .21$ is higher than overweight which is $.03 \pm .17$, and there is no statistically significance difference observed in two group.($p > 0.05$)
- f) PCV/Hematocrit (%)-The mean value of hematocrit in underweight i.e. 37.8 ± 5.63 is lower than overweight i.e. 41.4 ± 6.01 and is significant at p value of 0.00($p < 0.005$)
- g) MCV (fl)- The mean value of MCV in underweight i.e. 89.2 ± 6.03 is lower than overweight i.e. 89.8 ± 2.18 , and there is no statistically significance difference observed in two group.($p > 0.05$)
- h) MCH (pg)- The mean value of MCH in underweight i.e. $30.0 \pm .95$ and $30.1 \pm .78$ in overweight, and there is no statistically significance difference observed in two group.($p > 0.05$)

- i) MCHC (%) - The mean value of MCHC in underweight i.e. 33.56 ± 1.03 and $33.53 \pm .49$ in overweight, and there is no statistically significance difference observed in two group. ($p > 0.05$)
- j) ESR (mm/hr.) - The mean value of ESR in underweight which is 8.13 ± 6.4 and 8.65 ± 7.15 in overweight and there is no statistically significance difference observed in two group. ($p > 0.05$)

It can be summarized that hematological parameters such as Hemoglobin, Total leukocyte count, Platelet count, eosinophil and PCV were significantly different between underweight and overweight individuals. However RBC count, Neutrophil, Leucocyte, Monocyte, Basophil, ESR, MCV, MCH, and MCHC did not show significant differences between the two groups.

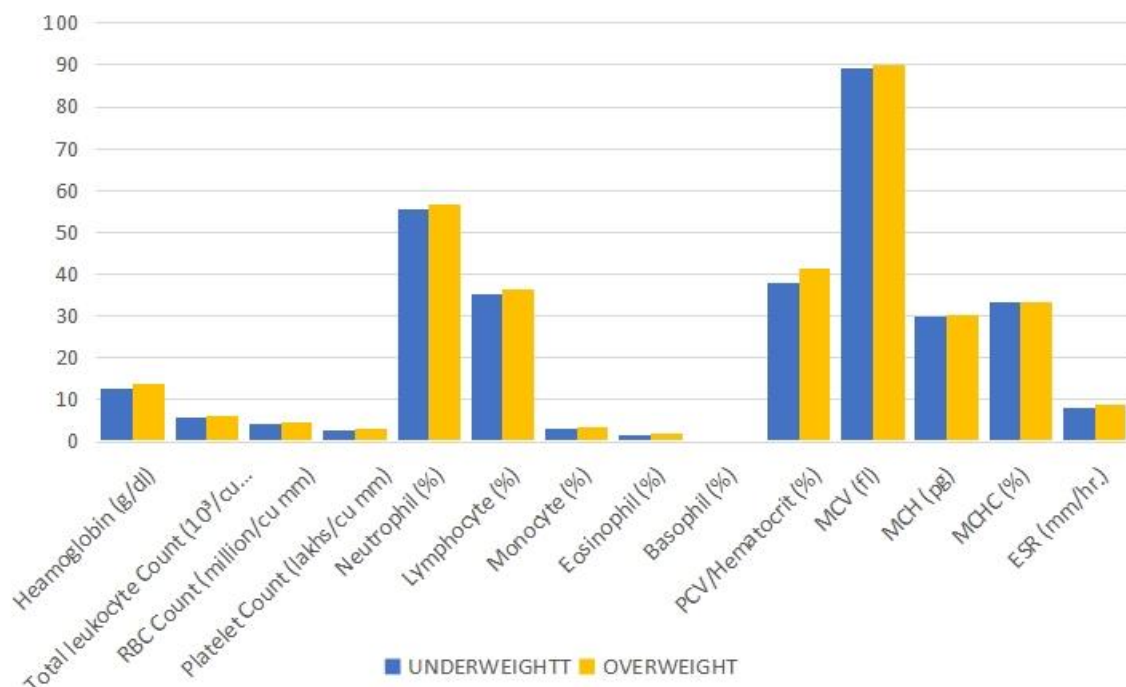


Figure.5.3. Comparison of hematological parameters between underweight and overweight.

PARAMETERS	UNDERWEIGHT MALE (n=50) (mean± SD)	UNDERWEIGHT FEMALE (n=50) (mean± SD)	P value
Hemoglobin (g/dl)	14.0±1.37	11.5±1.42	.000<0.05
Total leukocyte Count (10 ³ /cu mm)	5933±2053.7	5331±1609.2	.095>0.05
RBC Count (million/cu mm)	5.27±4.16	3.82±0.46	.01<0.05
Platelet Count (lakhs/cu mm)	2.42±7.30	2.59±6.76	.22>0.05
Neutrophil (%)	55.9±8.5	55.6±6.4	.87>0.05
Lymphocyte (%)	34.4±5.5	35.8±4.6	.14>0.05
Monocyte (%)	4.0±1.9	2.47±1.46	.00<0.05
Eosinophil (%)	2.21±1.48	1.2±1.1	.00<0.05
Basophil (%)	0.08±.27	0.02±0.13	.11>0.05
PCV/Hematocrit (%)	41.8±4.2	34.3±4.1	.00<0.05
MCV (fl)	89.7±1.5	88.7±8.07	.43>0.05
MCH (pg)	30.1±0.8	30.0±1.07	.54>0.05
MCHC (%)	33.5±0.64	33.6±1.27	.64>0.05
ESR (mm/hr)	4.2±4.1	11.4±6.2	.00<0.05

Table.5.3. Comparison of hematological parameters in male and female of underweight

INTERPRETATION-

Table.5.3. shows the comparison of hematological parameters in male and female of underweight.

This can be summarized that, in underweight males and females, Haemoglobin, RBC count, DLC (Monocyte, Eosinophil), PCV and ESR were significantly different between underweight males and females and Total leukocyte count, Platelet count, DLC(Neutrophil, Lymphocyte, Basophil), MCV, MCH, and MCHC did not show significant differences between underweight males and females.

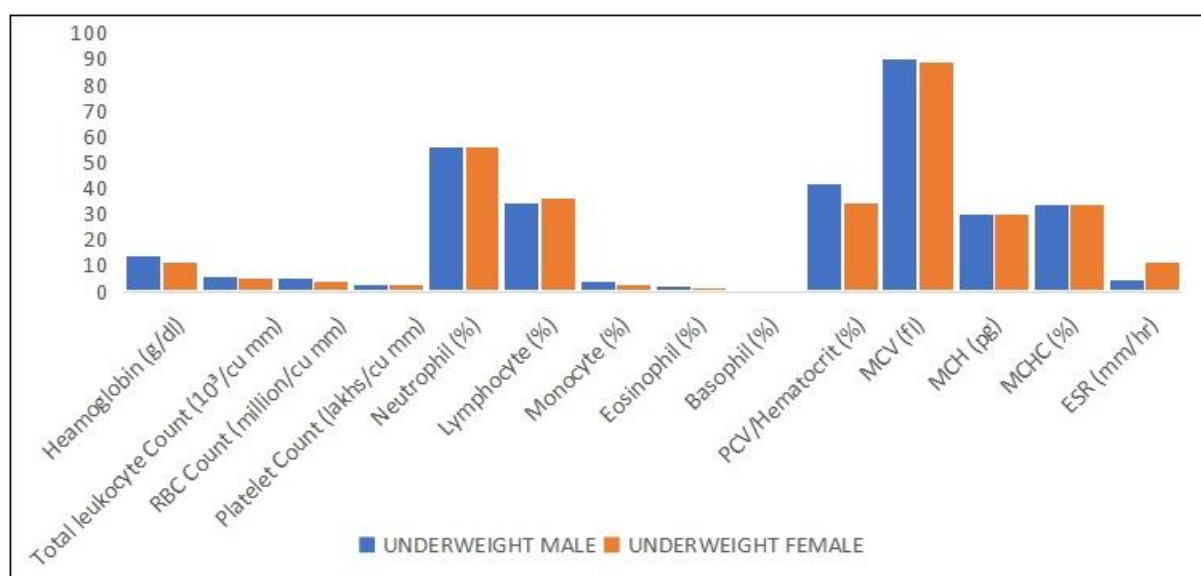


Figure.5.4. Comparison of hematological parameters in male and female of underweight

PARAMETERS	OVERWEIGHT MALE (n=50) (Mean±SD)	OVERWEIGHT FEMALE (n=50) (Mean±SD)	P value
Hemoglobin(g/dl)	15.1±1.2	12.5±1.6	0.00<0.05

Total Leucocyte Count (10 ³ /cu mm)	6597.7±2094.7	5944.7±1491.1	0.09>0.05
RBC count (million /cu mm)	4.9±0.50	4.1±.58	0.00<0.05
Platelet Count (lakhs/cu mm)	3.01±1.01	3.04±9.02	0.87>0.05
Neutrophil (%)	56.8±6.1	57.0±6.4	0.88>0.05
Lymphocyte (%)	35.6±3.5	37.3±5.7	0.08>0.05
Monocyte (%)	3.9±2.1	2.9±1.8	0.01<0.05
Eosinophil (%)	2.7±1.9	1.4±0.93	0.00<0.05
Basophil (%)	.04±.19	.02±.15	0.67>0.05
PCV (%)	45.0±3.9	37.0±5.1	0.00<0.05
MCV (fl)	90.1±2.4	89.5±1.7	0.22>0.05
MCH (pg)	30.2±0.84	30.0±.71	0.41>0.05
MCHC (%)	33.5±0.32	33.5±.64	0.95>0.05
ESR (mm/ hr)	4.8±3.6	13.2±7.6	0.00<0.05

Table.5.4. Comparison of hematological parameters in male and female of overweight.

INTERPRETATION-

Table 5.4. indicates the comparison of hematological parameters in male and female of overweight.

- The results of this can be summarized that the hematological parameters such as Hemoglobin, RBC count, monocyte , eosinophil , PCV, and ESR show statistically significant differences between overweight males and females.
- Total leucocyte count, platelet count,DLC(neutrophil , leucocyte , basophil) ,MCV, MCH, and MCHC do not show statistically significant differences between the two groups.
- These findings indicate that while some blood parameters significantly differ between overweight males and females, others do not, suggesting potential gender-specific variations in certain hematological parameters among overweight individuals.

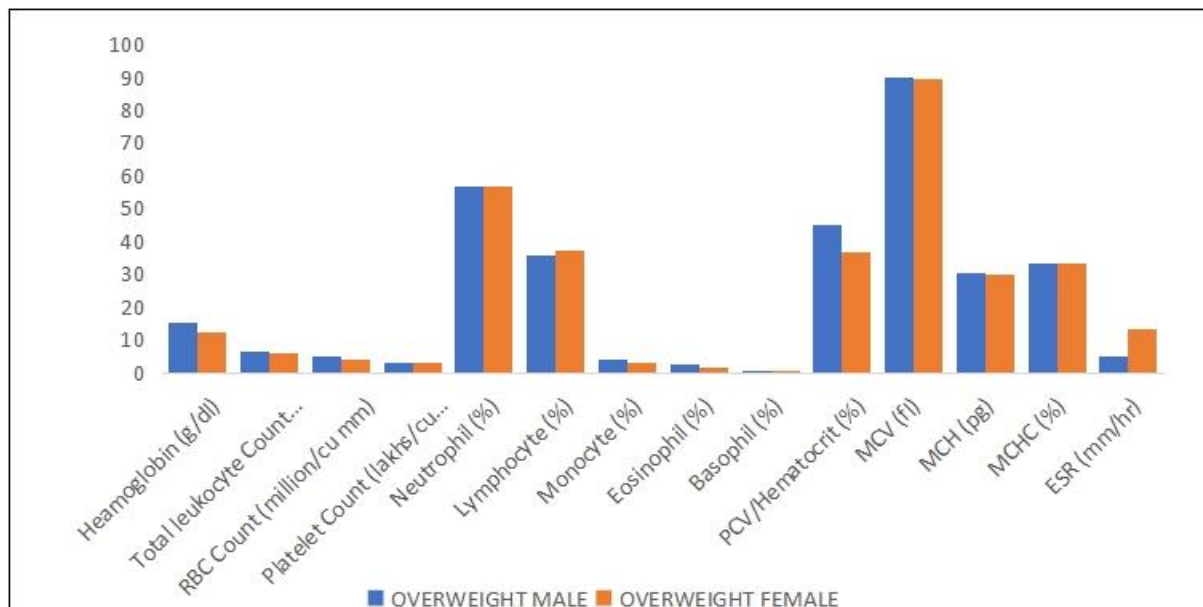


Figure.5.5. Comparison of hematological parameters in male and female of overweight

PARAMETERS	UNDERWEIGHT FEMALE (n=50) (Mean± SD)	OVERWEIGHT FEMALE (n=50) (Mean± SD)	P value
Hemoglobin (g/dl)	11.5± 1.4	12.5± 1.6	0.001<0.05
Total Leucocyte Count (10 ³ /cu mm)	5331.0± 1609.2	5944.7± 1491.1	0.04<0.05
RBC Count (million/cu mm)	3.82±0 .46	4.1± 0.58	0.00<0.05
Platelet count (lakhs/ cu mm)	2.59± 6.76	3.04± 9.02	0.00<0.05
Neutrophil (%)	55.6± 6.40	57.0± 6.41	0.31>0.05
Lymphocyte (%)	35.8± 4.6	37.3± 5.7	0.14>0.05
Monocyte (%)	2.4± 1.4	2.91± 1.8	0.18>0.05
Eosinophil (%)	1.2± 1.1	1.4± 0.93	0.27>0.05
Basophil (%)	0.02±0 .13	0.02±0 .15	0.84>0.05
PCV (%)	34.3± 4.17	37.0± 5.1	0.00<0.05
MCV (fl)	88.7± 8.07	89.5± 1.7	0.52>0.05
MCH (pg)	30.01± 1.07	30.0±0 .71	0.66>0.05
MCHC (%)	33.6± 1.2	33.5± 0.64	0.73>0.05
ESR (mm/hr)	11.4± 6.2	13.2± 7.6	0.18>0.05

Table.5.5. Comparison of hematological parameters between underweight and overweight female

INTERPRETATION-

Table.5.5. indicates the comparison of hematological parameters between underweight and overweight female.

- In this, the hematological parameters such as -Hemoglobin, RBC count, platelet count, total leucocyte count and PCV show statistically significant differences between underweight and overweight females.
- DLC (Neutrophil, lymphocyte , monocyte , eosinophil , basophil) , MCV, MCH, MCHC and ESR do not show statistically significant differences between the two groups.
- These findings suggest that weight status such underweight vs. overweight may influence certain hematological parameters in females, highlighting potential differences in physiological responses to weight changes.

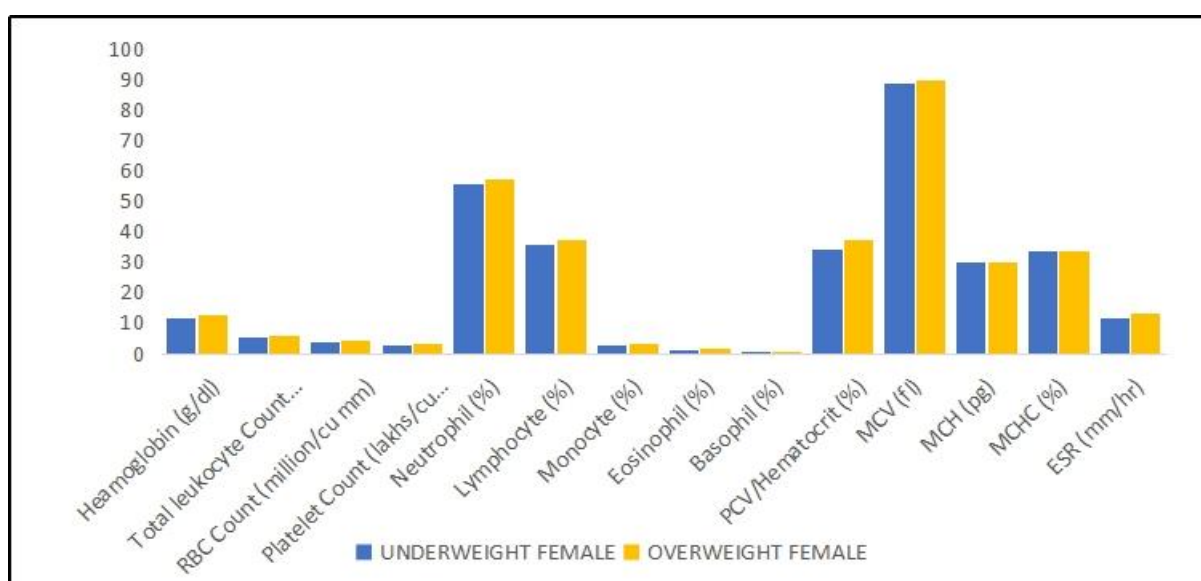


Figure 5.6. Comparison of hematological parameter between underweight and overweight female.

PARAMETERS	UNDERWEIGHT MALE (n=50) (Mean± SD)	OVERWEIGHT MALE(n=50) (Mean± SD)	P value
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Heamoglobin (g/dl)	14.0±1.3	15.1±1.2	0.00<0.05
Total Leucocyte Count (10 ³ /cu mm)	5933.3±2053.7	6597.7±2094.7	0.11>0.05
RBC Count (million/cu mm)	5.27±4.16	4.9±0.50	0.58>0.05
Platelet Count (lakhs/ cu mm)	2.42±7.30	3.01±1.01	0.00<0.05
Neutrophil (%)	55.9±8.5	56.8±6.1	0.54>0.05
Lymphocyte (%)	34.4±5.5	35.6±3.5	0.16>0.05
Monocyte (%)	4.0±1.9	3.9±2.1	0.77>0.05
Eosinophil (%)	2.2±1.4	2.7±1.9	0.10>0.05
Basophil (%)	0.08±0.27	0.04±0.19	0.35>0.05
PCV (%)	41.8±4.2	45.0±3.9	0.00<0.05
MCV (fl)	89.7±1.5	90.1±2.4	0.32>0.05
MCH (pg)	30.1±.80	30.2±0.84	0.54>0.05
MCHC (%)	33.5±.64	33.5±.32	0.87>0.05
ESR (mm/hr)	4.2±4.1	4.8±3.6	0.44>0.05

Table.5.6. Comparison of hematological parameters between underweight and overweight male-

INTERPRETATION-

Table.5.6. shows the comparison of hematological parameters between underweight and overweight male.

- Hemoglobin, platelet count, and PCV show statistically significant differences between underweight and overweight males. Overweight males tend to have higher hemoglobin levels, platelet counts, and PCV values.
- Total leucocyte count, RBC count, DLC(neutrophil, lymphocyte, monocyte , eosinophil , basophil) , MCV, MCH, and MCHC do not show statistically significant differences between the groups.
- ESR also does not differ significantly between underweight and overweight males, indicating that the inflammatory response, as measured by ESR, is similar across both groups.

- These findings suggest that while weight status affects some hematological parameters related to oxygen transport and clotting, other aspects of blood composition and inflammatory markers (ESR) do not vary significantly based on weight alone in males.

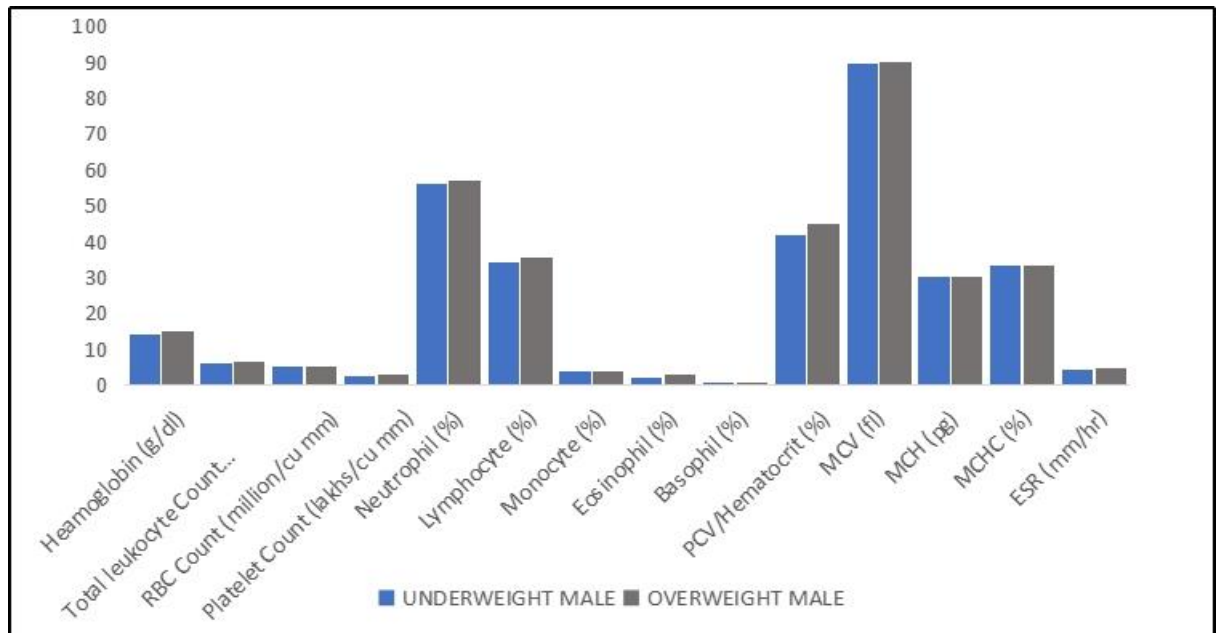


Figure.5.7. Comparison of hematological parameters between underweight and overweight male.

5.3. Hypothesis-

From this observations, the null hypothesis(i.e. there is no difference in the hematological parameters between underweight and overweight individuals) is rejected.

The alternative hypothesis(i.e. there is a significant difference in hematological parameters between underweight and overweight individuals) is retained.

CHAPTER-6

DISCUSSION

The aim of the present study was to evaluate the correlation of hematological parameters with body mass index among the students. The fifty percent (50%) of the population were males while other fifty percent (50%) were females, age group 18-27 years.

In this study, the underweight individuals generally exhibit lower levels of hemoglobin, total leukocyte count, platelet count, eosinophil and PCV compared to overweight individuals. These differences are statistically significant ($P < 0.05$). Other parameters such as RBC count, various leukocyte percentages, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), and erythrocyte sedimentation rate (ESR) did not show significant differences between the two groups.

□ The comparison of hematological parameters based on the gender it is observed that, in male and female of underweight .i.e. Haemoglobin, RBC count, Monocyte, Eosinophil, PCV and ESR were significantly different between underweight males and females and Total leukocyte

count, Platelet count, DLC(Neutrophil, Lymphocyte, Basophil), MCV, MCH, and MCHC did not show significant differences between underweight males and females.

a) The comparison of hematological parameters in male and female of overweight, the hematological parameters such as Hemoglobin, RBC count, monocyte, eosinophil, PCV, and ESR show statistically significant differences between overweight males and females. And Total leucocyte count, platelet count, DLC (neutrophil, lymphocyte, basophil), MCV, MCH, and MCHC do not show statistically significant differences between the two groups.

b) The comparison of hematological parameters between underweight and overweight female, Hemoglobin, RBC count, platelet count, and PCV show statistically significant differences between underweight and overweight females. And Total leucocyte count, DLC (neutrophil, lymphocyte, monocyte, eosinophil , basophil), MCV, MCH, and MCHC do not show statistically significant differences between the two groups.

c)The comparison of hematological parameters between underweight and overweight male. Hemoglobin, platelet count, and PCV show statistically significant differences between underweight and overweight males. Overweight males tend to have higher hemoglobin levels, platelet counts, and PCV values. The Total leucocyte count, RBC count, DLC (monocyte, eosinophil , basophil and lymphocyte), MCV, MCH, MCHC and ESR do not show statistically significant differences between the groups.

□The associations between hematological parameters with body mass index

In this study shows that statistically significant increase in the mean value of Hb (13.9 ± 1.94), total leucocyte count (6302.2 ± 1865.7), platelet (3.02 ± 9.63) and hematocrit (41.4 ± 6.01) higher in the overweight group compared to the underweight group. The findings of this study similar with the previous study reported by H.R.Jeong et al¹⁷ also observed that higher BMI was associated with elevated WBC, RBC, Hb, Hct, and platelet counts in adolescents. Because higher levels of hematological parameters are potential risk factors for obesity-related diseases, hematological parameters should be evaluated in obese children and adolescents. Our results were similar to the study performed by K. Meena³⁰ in which they concluded that Hb and PCV increases with an increase in BMI, in hypertensive patients. Overweight individuals have significantly higher hemoglobin levels compared to underweight individuals. This suggests a possible association between higher body weight and higher hemoglobin levels.

The present findings are similar with the latter, in which they included that the increase of total leucocyte count was observed among the overweight participants reported by A. Alrubaie et al²³ and C. Prasad et al⁷⁵. Overweight individuals show a significantly higher total leukocyte count compared to underweight individuals. This could indicate differences in immune response or chronic inflammation associated with higher body weight. The study findings revealed that the mean value of lymphocyte in underweight i.e. 35.1 ± 5.07 is lower than overweight i.e. 36.4 ± 4.72 , and there is no statistically significance difference observed in two group. ($p > 0.05$), this studies consistent with the study done by T. Nishida et al^{37,39} in which they concluded that lower lymphocyte with underweight. This study suggests that being severely underweight and on restricted food intake for weight loss in adult women can be risk factors for low lymphocyte count, an indicator of malnutrition.

The results were in contrast to O.I Ajayi et al⁴¹ in which they observed a significantly increased neutrophil and platelet counts in the subjects with BMI > 25 kg/m². the overweight or obesity was also observed to be positively correlated with the neutrophil, monocyte counts and MCV of haemoglobin AS and SS genotype groups in this study.

This study show no significant difference in MCV between underweight and overweight and the results are same with SU. Abro, et al⁵¹ in which they concluded that MCV had no significant ($p > 0.001$) association of study participants to different categories of Body Mass Index.

The mean value of MCH in underweight i.e. $30.0 \pm .95$ and $30.1 \pm .78$ in overweight, and the mean value of MCHC in underweight i.e. 33.56 ± 1.03 and $33.53 \pm .49$ in overweight , and there is no statistically significance difference observed in two group. ($p > 0.05$), and there is no statistically significance difference observed in two group. ($p > 0.05$) our findings were contrast to the study reported concluded that Mean corpuscular hemoglobin and Mean corpuscular hemoglobin concentration had statistically significant ($p < 0.001$) association with body mass index (BMI)⁵¹.

This study show that in platelet count mean value in underweight i.e. 2.51 ± 7.03 is lower than the overweight i.e. 3.02 ± 9.63 and is significant at p value of 0.00 ($p < 0.005$), which is similar to O.I Ajayi et al⁴¹ findings.

This study show that mean value of hematocrit in underweight i.e. 37.8 ± 5.63 is lower than overweight i.e. 41.4 ± 6.01 and is significant at p value of 0.00 ($p < 0.005$), similar to C. Prasad

et al⁷⁵, they observed higher PCV in overweight and obese individual groups when compared to underweight and normal weight BMI groups. while others results of this study shown that Packed cell volume among males was higher $47.45 \pm 3.409\%$ than for females $39.90 \pm 3.169\%$, with a difference statistically significant ($p= 0.000$). However, some study reported that no significant difference in PCV when compared between obese individuals and nonobese individuals based on age group respectively⁷⁷

In this study, our findings shown that ESR were significantly different between underweight males and females similar to the study performed by E. Cohen et al⁷¹ in which they included that there was ESR difference was found to be greater in women than in men.

CONCLUSION

CHAPTER-7

In this study, the different hematological parameters were performed on a total of 200 in the apparently healthy individual of RIPANS. Elucidating the correlation between hematological parameters and BMI enhances clinical understanding, informs healthcare practices, guides public health initiatives, drives research advancements, and facilitates personalized patient care. This comprehensive approach contributes to improved health outcomes and quality of life for individuals affected by obesity and associated hematological implications. Hematological parameters are crucial for diagnosing and monitoring various diseases such as anemia, infections, autoimmune disorders, and cancers. They provide insights into the body's immune response, oxygen transport, and clotting mechanisms. Changes in these parameters can indicate underlying health issues or response to treatment.

BMI is a measure of body fat based on height and weight. The formula for BMI = weight (kg) / height² (m²).

Classification:

Underweight: BMI < 18.5

Normal weight: BMI 18.5 - 24.9

Overweight: BMI 25 - 29.9

Obesity: BMI $\geq$ 30

Significance:

BMI is used as a screening tool to assess risk for health problems related to weight. It correlates with body fat and helps in categorizing individuals into weight-related health risk groups.

High BMI is associated with increased risk of chronic conditions such as diabetes, cardiovascular diseases, hypertension, and certain cancers.

Low BMI may indicate malnutrition or certain health conditions like osteoporosis.

In conclusion, while hematological parameters focus on blood health and immune function, BMI provides insights into weight-related health risks. Both are essential in assessing and managing overall health and identifying potential underlying health issues.

From the present study it can be concluded that

- Hemoglobin Levels: Generally, overweight individuals (both male and female) tend to have higher hemoglobin levels compared to underweight individuals.
- Total Leucocyte Count and Platelet Count: Overweight individuals have higher total leukocyte and platelet counts compared to underweight individuals.
- Gender Differences: Males (both underweight and overweight) tend to have higher RBC counts and PCV compared to females. Females, especially overweight, tend to have higher ESR values compared to males.
- Other Parameters: No significant differences were found in RBC count, neutrophil percentage, leucocyte percentage, MCV, MCH, and MCHC between underweight and overweight groups across genders.

These findings underscore the importance of considering nutritional status and gender in interpreting hematological parameters. These interpretations should guide further investigation into the underlying factors contributing to these differences and their clinical implications.

CHAPTER-8

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