



Original Article

Association of Body Mass Index Changes with Hematological Parameters and Alterations – A Cross Sectional Analysis

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ABSTRACT

Introduction: Obesity is defined as excessive accumulation of fat in various tissues in the body which causes ill health in the body. The basic cause of obesity is imbalance between calories intake and calories expenditure. There is increased intake of calorie rich foods and reduced physical activity due to urbanization all over the world. There has been lot of debate and discrepancy related to the significance of body mass index and hematological profile in individuals – obese and lean. The crux of the problem has to be delineated with means of further research and in depth analysis which happens to be the main motto of this study.

Aim: To evaluate the alteration of hematological parameters in relation to Body Mass Index (BMI).

Objectives: To describe alterations of various hematological parameters in relation to the changes in BMI.

Materials and Methods: It is a cross-sectional prospective study conducted in a tertiary care hospital from a period of June 2025 to May 2026. The individuals were classified into four different groups based on Body mass index – (Group A – BMI <18.5 kg/m² [n=31]; Group B – BMI <18.5–25 kg/m² [n=60]; Group C – BMI >25 kg/m² [n=160] and Group D – BMI >30 Kg/m² [n=44]); with total of 295 individuals attending out-patient departments and are undergoing complete Blood Picture (CBP) with Peripheral smear has been performed with automated cell counter and manual technique using Leishman's stain respectively. The slides were evaluated under microscope (100x) oil immersion. All findings were tabulated and statistical analysis was performed using Microsoft Excel and R software.

Results: Obesity was observed more commonly in young adult age group between 31-40 years and is predominantly reported in females. There is remarkable depression in Hemoglobin, RBC, Hematocrit, MCV and MCH in Group D. RDW is raised and showed significant increase in both Group C and Group D individuals.

Conclusion: Obesity and underweight never present with specific clinical features. Majority are asymptomatic and leave very non-specific impact over the hematological profile of these individuals. The spectrum of obesity demand diverse hematological investigations to diagnose the hematological manifestations and alterations.

INTRODUCTION

Obesity is defined as excessive accumulation of fat in various tissues in the body which causes ill health in the body. The basic cause of obesity is imbalance between calories intake and calories expenditure. There is increased intake of calorie rich foods and reduced physical activity due to urbanization all over the world. [1]

Body mass index is simple formula to classify obesity in adults. It is defined as person's weight in kilograms divided by height in meter squares (m^2).

Obesity and elevated BMI are the major causes for development of chronic diseases like stroke, hypertension, Type 2 diabetes and other cardiovascular disorders [2]. BMI is the modifiable risk factors of type 2 diabetes, hypertension, stroke and cardiovascular diseases. This study was undertaken to assess the relationship between BMI and haematological profile among young Indian population. [3]

Hematologists have always had a keen interest in researching the pathophysiology and clinical relevance of hematological parameters in various populations. Factors that may affect hematological and serum biochemical parameters might include gender, age, body mass index (BMI), season, and nutrition. [4]

The association between Hemoglobin and BMI is currently unknown. Studies have reported that obesity has an adverse effect on iron concentration that can lead to derangements in blood parameters including hemoglobin (Hb) and red blood cell (RBC) count so more research is needed to determine whether Hb might serve as a how many red blood cells are present in the blood [5]. The WBC count indicates how many white blood cells (WBC) are present in the blood. Obesity is known to be associated with chronic low-grade inflammation, which can increase the WBC count [6]. A substantial correlation between platelet count and BMI has been observed in certain research works. [7,8]

Thus, there has been lot of debate and discrepancy related to the significance of body mass index and hematological profile in individuals – obese and lean i.e., underweight. The crux of the problem has to be delineated with means of further research and in depth analysis which happens to be the main motto of this study.

MATERIAL AND METHODS

Study design: Prospective cross-sectional analytical study performed at a tertiary care hospital from May 2025 to June 2026. The status of body mass index is correlated with alteration of hematological parameters in those individuals.

Study population: A total of 295 individuals were included in the study accounting for 31 (10.5%) under weight; 60 (20.3%) normal weight; 160 (54.2%) over weight and 44 (14.9%) obese individuals. The individuals who were attending General out-patient department of Medicine, Surgery, Gynecology without any major ailments and those who approached to central laboratory for complete blood picture and other hematological tests were selected.

Inclusion criteria: All individuals above 18 years of age with no major health disturbances and have consented to be a part of the study were included.

Exclusion criteria: Patients with pre-existing hematological disorders before getting diagnosed with under weight related and obesity related complications. Pregnant women, patients with history of recurrent infections, allergy, drug intake which affects hematological parameters (viz., anti-cancer therapy, anti-coagulants; intravenous antibiotics).

Ethical consideration: As a statutory requirement, the study is registered with institutional scientific committee with approval no: Rc.No. 11. Pro.No: 1/RAC/MRU/SVMC Dt: 11-02-2025, and permission obtained from Institutional ethics committee with respect to Lr.No.15/2025 on 08/05/2025. Relevant informed and written consent was obtained from all the participants of the study.

Statistical analysis: The details were tabulated in Microsoft Excel software and basic statistical analysis likely – Mean, Standard deviation, p-value calculation was carried out. All categorical variables were designated as frequency and percentages. All the continuous variables are expressed as mean and standard deviation. One way ANOVA test was performed for comparative analysis of hematological parameters in individuals with altered body mass index and normal body mass index using R programming language for statistical computing and data visualization (freeware) stable release version 4.4.2 (2024). The p value of <0.05 was considered statistically significant.

Data collection and Procedure:

Body Mass Index Work-up: -

1. Adults >18 years of age individuals attending outpatient department of SVRR Govt. General Hospital were counselled and included in the study. A written and informed consent was obtained.
2. The normal clinical history along with physical examination was performed. Baseline parameters viz., Pulse rate, Blood Pressure and Temperature were recorded to ascertain normal basal metabolic rate.
3. Body Mass Index of all individuals was calculated by recording the height in meters and weight in kilograms. The individuals are classified into 4 different groups based on BMI. (Group A – BMI <18.5 kg/m² - underweight; Group B – BMI 18.5–25 kg/m² – normal weight;; Group C – BMI >25 kg/m² – over weight and Group D – BMI >30 Kg/m² - obese)

The blood sample was collected under aseptic precautions from venipuncture technique from left ante cubital fossa – medial cubital vein. Five ml of blood was drawn in vacutainer. The sample collected in EDTA tube was subjected for complete blood picture with hemogram; which was performed with the aid of Erba Mannheim Elite 580 – 5 part – automated laboratory hematology analyzer. RBC, WBC, Platelet related parameters were studied. Peripheral blood smears were prepared and air dried glass slides were stained by Leishman stain solution. All the stained smears were evaluated for morphological and pathological abnormalities if any under the microscope preferably in 100x (oil immersion) magnification. All studied parameters were tabulated accordingly to establish the relationship of body mass index of individuals with complete blood picture and peripheral smear and all parameters are evaluated and studied in depth with emphasis on body mass index status of the individual and type of anemia.

RESULTS

The cumulative findings of the research have showed that obesity was commonly seen in young adults between 31-40 years, whereas underweight was observed in 21-30 years age group. Overall female predominance was observed in obese individual group. (Table no. 1).

Based on body mass index – the participants were divided into four groups namely, Underweight; Normal weight; Overweight and Obese based on their Body Mass Index values (Table no. 2). There is significant depression in the mean RBC count, hemoglobin percentage, hematocrit, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH) and mean corpuscular hemoglobin concentration (MCHC) in contrast with elevation of red cell distribution width (RDW) in both obese and underweight groups when compared against the normal BMI group of individuals. MCV; MCH & MCHC have revealed no statistically significant difference in underweight (Table no. 2).

It is observed that there is no statistically significant difference in total leucocyte count and platelet count when compared between all four groups of participants. Differential leucocyte count analysis showed statistically significant difference in all the cells in both the obese and underweight group of individuals compared to normal BMI group of participants and overweight group of individuals. (Table no. 3).

Peripheral blood evaluation revealed a different picture – where 12 (4.06%) of underweight patients show anemia and 26 (8.81%) obese individuals show anemia. Most common type of anemia noticed was dimorphic anemia 42 (14.23%) in both obese and underweight individuals followed by normocytic normochromic picture – 18 (6.10%) and 15 (5.08%) show microcytic hypochromic type of anemia.

Table No. 1: Classification of individuals based on age and sex with respect to BMI status.

Sl.no	Sex	Body Mass Index based group	Age in years					Total (%)
			21-30	31-40	41-50	51-60	>60	
1.	Male	Under weight	3	4	2	2	1	12 (4.06)
2.		Normal weight	12	6	7	2	1	28 (9.49)
3.		Over weight	21	40	8	4	2	75 (25.4)
4.		Obese	8	6	3	2	2	21 (7.11)
		Total Male						136 (46.1)
5.	Female	Under weight	7	5	3	2	2	19 (6.44)
6.		Normal weight	8	10	6	4	4	32 (10.8)
7.		Over weight	24	42	12	6	1	85 (28.8)
8.		Obese	6	8	3	4	2	23 (7.79)
		Total Female						159 (53.8)
		Grand Total						295 (100)

Table no. 2: Comparative analysis of Red blood cell (RBC) parameters among study groups

Red blood cell parameters	Under weight (n = 31) Mean +/- Standard Deviation (SD)	Normal weight (n=60) Mean +/- Standard Deviation (SD)	Over weight & Obese (n=204) Mean +/- Standard Deviation (SD)	P value P1 = p value of Underweight p2 = p value of Overweight & obese
RBC (in million/cu.mm)	2.9+/-0.75	3.2+/-0.55	4.8+/-0.83	<i>p1=0.0001</i> <i>p2=0.0001</i>
Hemoglobin (gm %)	8.7+/-1.72	10.2+/-1.72	13.24+/-1.82	<i>p1=0.0001</i> <i>p2=0.0001</i>
Hematocrit (%)	25.24+/-5.82	35.82+/-7.26	44.24+/-4.28	<i>p1=0.0001</i> <i>p2=0.0001</i>
MCV (femtolitres)	82.64+/-6.24	83.26+/-3.88	84.23+/-7.88	<i>p1=0.022</i> <i>p2=0.124</i>
MCH (picograms)	25.37+/-3.14	26.36+/-2.16	30.18+/-1.82	<i>p1=0.029</i> <i>p2=0.251</i>
MCHC (g/dl)	28.12+/-3.12	29.54+/-2.11	30.24+/-1.56	<i>p1=0.036</i> <i>p2=0.328</i>
RDW (%)	12.98+/-0.8	13.28+/-0.58	11.94+/-0.58	<i>p1=0.0001</i> <i>p2=0.0001</i>

Table no. 3: Comparative analysis of White blood cell (WBC) and Platelet observations among study groups

WBC & Platelets	Under weight (n = 31) Mean +/- Standard Deviation (SD)	Normal weight (n=60) Mean +/- Standard Deviation (SD)	Over weight & Obese (n=204) Mean +/- Standard Deviation (SD)	P value P1 = p value of Underweight p2 = p value of Overweight & obese
WBC – Total leucocyte count (X 1000 cells/cu.mm)	6.84+/-2.21	7.14+/-2.46	7.86+/-2.66	<i>p1=0.62</i> <i>p2=0.91</i>
Platelets (lakhs/cu.mm)	1.98+/-0.81	2.24+/-1.14	264+/-1.05	<i>p1=0.092</i> <i>p2=0.51</i>

DISCUSSION

Anemia is ever evolving and major health problem in India and all the developing and under developed countries of the world [9]. Deficiency of one or more nutrients required for haemopoiesis results in below normal average concentration of hemoglobin which in turn leads to nutritional anemia [10]. Anemia was found in 70 (23.7%) which is a similar finding in a study performed by Waseem et al., [11] Majority of female subjects in all groups showed anemia. There have been significant differences between Hemoglobin, MCV, MCH, MCHC levels of anemic and non-anemic subjects in both genders. A similar study undertaken by Manjula VD et al., [12] presents that, Hb, MCH, MCV, MCHC were significantly on a lesser side in anemic individuals when compared to non-anemic individuals irrespective of Body mass index status. It has also been noticed that, there is increased hematocrit in overweight and obese groups in both males and females, with female majority. Focal increase of hematocrit can be considered as a marker or risk factor for cardiovascular disturbances and strokes. Increased viscosity of blood is seen with increased hematocrit values in obese individuals, which in turn is a strong marker of cardiovascular changes and added risk factors [13-15].

In present study, it is reported that, there has been significant increase in WBC count in overweight and obese group compared to normal weight and underweight groups. Females show increased WBC counts compared to males. The probable explanation for the above scenario can be attributed to hypertrophy and hyperplasia of adipocytes leading to release of inflammatory leucocytes [2,15]. The onset of metabolic syndrome in obese subjects can be a catcher which can be a forerunner for diseases like atherosclerosis and other cardiovascular diseases. There are some contrast findings which showed that, obese individuals are more susceptible to infections and possible impaired granulopoiesis can lead to bacterial growth and upcoming infections [16].

In present study, there has been a relevant trend observed with changes in platelet count. The obese individuals showed mild decrease in platelet count when compared to all other individuals in absence of relevant complaints. There have been similar findings with study performed by Lucy et al., [17] with increase in immature platelets and decrease in platelets with individuals having increased body mass index and BMI disturbances.

CONCLUSION

The patients with underweight and obesity present with vague and non-specific clinical features related to hematological alterations. Thus, there exists a specific need for a thorough hematological analysis in all patients having body mass index disturbances. In same manner, long standing refractory anemias demand the evaluation of patient with body mass index analysis. This emphasizes the standard role of hormones related to body mass index disturbances in regulation of erythropoiesis which in turn controls numerous hematological parameters. The female population of younger age group is hardly hit members with cumulative body mass index disturbances along with alteration of hematological parameters, especially in young and fertile phase of life. Thus, this happens to ring the alarm for the need and special address to be noted and undertaken in these individuals with schematic and strategic approach of diagnosis and management of body mass index dependent medical and surgical ailments and hematological manifestations – especially anemia.

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Authors' Contributions'

Dr. N.Nusrath : concept and design of the study, acquisition of data, statistical analysis, drafting of the manuscript.

Dr. Md Kadher Faheem.N : concept and design, interpretation of data, critical revision of the manuscript.

Dr. Shahanuma Shaik & Dr.C.Sushma : laboratory supervision, interpretation of data, critical revision, clinical supervision, interpretation of data, critical revision of the manuscript.

Dr.Madhusudhana P, Dr.Rekha, Dr.Indrani, Dr.A.S.Kireeti: Overall supervision, data analysis, statistical analysis advice, review of research work, Gantt chart periodic review.

All authors read and approved the final version of the manuscript to be published

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