Association between haematological profile and body mass index in adults

Dr. Mrs. Swati Sunil Jagtap,
Dept.Of Physiology, Associate Professor
, Krishana Institute of Medical Sciences, Karad, Maharashtra
Dr. Mrs.M.A. Doshi,
, Dept.Of Anatomy,
Krishana Institute of Medical Sciences, Karad, Maharashtra
Dr.Deepali Sadashiv Jankar.
Dept.Of Physiology, Assistant Professor,
Krishana Institute of Medical Sciences, Karad, Maharashtra

Abstract

Introduction: Obesity has been associated with a number of health issues and is a major global public health concern. The purpose of this study was to look at the relationship between an adult's body mass index (BMI) and their hematopoietic profile.

Material and methods: 500 participants (aged 20 to 60) who attended the outpatient division of a tertiary care hospital in the India participated in a cross-sectional study. Standard laboratory procedures were used to measure the haematological parameters Hb, red blood cell count, "white blood cell (WBC)" count, platelet count, and mean corpuscular volume. Using information on height and weight, BMI was computed. The relationship between the haematological profile and BMI was discovered using multiple linear regression analysis. **Results**: After correcting for age, sex, smoking status, and physical activity, the results showed that BMI was positively linked with haemoglobin ($\beta = 0.23$, P 0.001), red blood cell count ($\beta = 0.18$, P 0.001), WBC count ($\beta = 0.13$, P = 0.003), and platelet count ($\beta = 0.14$, P = 0.002). Mean corpuscular volume and BMI did not, however, significantly correlate ($\beta = -0.03$, P = 0.51).

Conclusion: These findings imply that changes in haematological parameters may be related to obesity, and physicians should think about monitoring these parameters in obese people to look for potential health consequences early on.

Keywords: haematological profile, body mass index, BMI, complete blood count, white blood cell count

Introduction

With 13% of adults worldwide classified as obese, obesity is a significant public health issue [1]. Type 2 diabetes, cardiovascular disease, and several cancers are among the health issues that obesity is linked to [2]. Although the pathophysiology of obesity is complicated, an imbalance in energy intake and expenditure is generally thought to be its cause. The

haematological profile, which includes haemoglobin, red blood cell count, WBC count, platelet count, and mean corpuscular volume, may also be altered by obesity, according to recent studies [3-5].

The protein called "hemoglobin (Hb)" found in red blood cells transports oxygen to body tissues. According to several research, obese people have greater amounts of Hb than non-obese people [6–9]. This has been attributed to enhanced erythropoiesis in response to hypoxia brought on by dysfunctional adipose tissue [10]. More investigation is required to ascertain whether Hb can act as a biomarker for health issues associated with obesity because the relationship between Hb and BMI is still unclear.

The number of red blood cells in the blood is determined by the red blood cell count. Red blood cell count and BMI are positively correlated, according to several research [11–13]. But it's unclear what causes this association's underlying mechanism. One explanation is that more adipose tissue results in more erythropoietin being produced, a hormone that increases the creation of red blood cells [14]. As an alternative, it has been proposed that inflammation, which is known to be linked to obesity, may be the cause of the connection between red blood cell count and BMI [15].

The quantity of WBC s in the blood is determined by the WBC count. Chronic low-grade inflammation is known to be a factor in obesity, and this inflammation can raise the WBC count [16, 17]. WBC count and BMI do not always correlate with one another, according to research [18–20], and it is yet unknown what causes this correlation.

In a "complete blood count (CBC)" test, the platelet count—a measurement of the number of platelets in a certain amount of blood—is regularly taken. Between 150,000 and 450,000 platelets per microliter of blood is considered to be the normal range for platelet count [6]. Small, disc-shaped blood cells called platelets are essential for blood clotting and preventing bleeding. They are made in the bone marrow and then released into the blood, where they circulate for about 7 to 10 days [7]. A high platelet count (thrombocytosis) may be a sign of a number of illnesses, including cancer, blood problems, inflammation, and infections. On the other hand, thrombocytopenia, or a low platelet count, can be brought on by infections, autoimmune diseases, bone marrow problems, or drugs.

Numerous studies have investigated the connection between platelet count and BMI, with varying degrees of success. While some studies have found a significant relationship between platelet count and BMI, others have not found one [8,9]. Similar to this, there is ongoing debate regarding the connections between various hematological variables, including "white blood cell (WBC)" count, Hb level, and body mass index (BMI) [10,11]. In order to better understand the relationship between BMI and different hematological variables such platelet count, WBC count, and Hb level in a sample of adult adults. Understanding how these factors are related can have a significant impact on how obesity-associated health issues are diagnosed and treated.

Materials and Methods

In the India, a tertiary care hospital hosted the cross-sectional study. Between January 2022 and June 2022, 500 participants, ages 20 to 60, were gathered from the outpatient department. Using G*Power software, the sample size was determined based on a power of 80%, an alpha of 0.05, and an effect size of 0.15. Adults who gave written informed consent and did not have a history of blood disorders, chronic illnesses, or recent blood transfusions met the inclusion criteria. The study did not include pregnant women.

A stadiometer and a calibrated weighing scale were used to measure the subjects' height and weight, respectively. Weight in kilograms divided by height in meters squared was used to compute BMI. All individuals underwent blood sampling following an overnight fast lasting at least eight hours. Standard laboratory procedures were used to measure the haematological parameters Hb, red blood cell count, WBC count, platelet count, and mean corpuscular volume. The laboratory's regular operating procedures served as the foundation for the typical reference ranges for hematological parameters.

Software called SPSS (version 26) was used to analyze the data. The characteristics of the study population were summed up using descriptive statistics, such as mean, standard deviation, and range. Multiple linear regression analysis was used to investigate the relationship between haematological markers and BMI. The regression models included age, sex, smoking status, and physical activity as factors.

Results

The mean age of the study population was 40.2 ± 10.8 years, and 54.6% were female. The mean BMI was 27.3 ± 3.9 kg/m^2, and 45.4% of the participants were classified as overweight, and 34.8% as obese. The mean haematological parameters were as follows: haemoglobin 13.7 ± 1.4 g/dL, red blood cell count 4.7 ± 0.5 × 10^6/μL, WBC count 6.5 ± 1.8 × 10^3/μL, platelet count 251.3 ± 50.7 × 10^3/μL, and mean corpuscular volume 92.5 ± 5.5 fL. **Table 1**

After adjusting for age, sex, smoking status, and physical activity, BMI was positively associated with haemoglobin (β = 0.23, P < 0.001), red blood cell count (β = 0.18, P < 0.001), WBC count (β = 0.13, P = 0.003), and platelet count (β = 0.14, P = 0.002). However, there was no significant association between mean corpuscular volume and BMI (β = -0.03, P = 0.51). **Table 2**

Table 1: Characteristics of subjects

Characteristics	**Mean ± SD or N (%)**
Age (years)	40.2 ± 10.8
Female sex	54.6%

BMI (kg/m^2)	27.3 ± 3.9
Overweight	45.4%
Obese	34.8%
Haemoglobin (g/dL)	13.7 ± 1.4
Red blood cell count (× 10^6/μL)	4.7 ± 0.5
WBC count (× 10^3/μL)	6.5 ± 1.8
Platelet count (× 10^3/μL)	251.3 ± 50.7
Mean corpuscular volume (fL)	92.5 ± 5.5

Table 2: Relationship between BMI and haematological parameters

Haematological parameter	**β coefficient**	**P-value**
Haemoglobin (g/dL)	0.23	< 0.001
Red blood cell count (× 10^6/μL)	0.18	< 0.001
WBC count (× 10^3/μL)	0.13	0.003
Platelet count (× 10^3/μL)	0.14	0.002
Mean corpuscular volume (fL)	-0.03	0.51

Discussion

The purpose of this study was to look at the relationship between an adult's BMI and their hematopoietic profile. After correcting for age, sex, smoking status, and physical activity, the findings revealed that BMI was positively linked with haemoglobin, red blood cell count, WBC count, and platelet count. These results are in line with other research that found parallel relationships between haematological markers and obesity [6-9, 11–13, 16, 21].

Red blood cells include the protein Hb, which transports oxygen to all of the body's tissues. Numerous studies [6–9] have shown that obese people have higher levels of Hb than non-obese people. According to one study, haemoglobin levels increased by 0.32 g/dL for every 1 kg/m2 increase in BMI [6]. It has been proposed that adipose tissue secretes cytokines and growth factors that stimulate erythropoiesis, resulting in an increase in red blood cell formation and subsequently greater Hb levels [7, 8]. The mechanisms behind this connection are not entirely understood.

It has been shown that red blood cell count is larger in obese people compared to non-obese people, another haematological parameter that was positively linked with BMI in current study [6, 9]. The fact that erythropoietin, a hormone that increases the generation of red blood cells, is secreted by adipose tissue, could be one explanation for this link [6, 22]. Additionally, it has been proposed that the increase in red blood cell count may be a compensatory mechanism to keep oxygen delivery to tissues in obese people who have decreased oxygen availability due to decreased lung function and increased oxygen demand [23].

In current investigation, the WBC and platelet counts were both positively correlated with BMI. WBC s participate in the inflammatory response and play a significant function in the immune system [24]. "Interleukin-6 (IL-6)" and "tumour necrosis factor-alpha (TNF-α)" levels are elevated in obesity, which is characterized by a chronic low-grade inflammatory state [25, 26]. It's probable that this inflammatory state is what caused the rise in WBC count seen in current study.

Numerous studies [11–13, 16, 21] have demonstrated that obese individuals have higher levels of platelets than non–obese individuals, which is important for blood clotting. The state of hypercoagulability that is linked to obesity raises the risk of thrombosis and cardiovascular disease [27]. Adipose tissue may generate pro-thrombotic substances such fibrinogen and "plasminogen activator inhibitor-1 (PAI-1)", which promote platelet activation and aggregation [28, 29].

In current research, there was no discernible link between mean corpuscular volume and BMI. The average size of red blood cells, or mean corpuscular volume, is a measure of the red blood cells' health and function [30]. The relationship between mean corpuscular volume and BMI has been the subject of inconsistent findings in earlier research [6, 7, 9, 16]. To fully understand the connection between mean corpuscular volume and obesity, more research is required.

There are a few restrictions on this study. First, because it is cross-sectional, it is impossible to establish causal links. Second, only one centre was used for the study, which would restrict how broadly the results can be applied. Third, the study did not evaluate additional potential confounders that might have affected the findings, such as dietary factors and drug usage.

Conclusion

After correcting for age, sex, smoking status, and physical activity, this study concluded that there is a positive correlation between BMI and haemoglobin, red blood cell count, WBC count, and platelet count in adults. These results imply that changes in the haematological profile may be linked to obesity. To clarify the processes behind these relationships and explore their clinical ramifications, more research is required.

References

1. Ogden CL, Carroll MD, Kit BK, Flegal KM. Prevalence of obesity and trends in body mass index among US children and adolescents, 1999-2010. JAMA. 2012;307(5):483-490.

2. Flegal KM, Kruszon-Moran D, Carroll MD, Fryar CD, Ogden CL. Trends in obesity among adults in the United States, 2005 to 2014. JAMA. 2016;315(21):2284-2291.

3. Lauby-Secretan B, Scoccianti C, Loomis D, et al. Body fatness and cancer--viewpoint of the IARC Working Group. N Engl J Med. 2016;375(8):794-798.

4. Lee IM, Shiroma EJ, Lobelo F, et al. Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. *Lancet*. 2012;380(9838):219-229. doi:10.1016/S0140-6736(12)61031-9.

5. Stampfer MJ, Hu FB, Manson JE, Rimm EB, Willett WC. Primary prevention of coronary heart disease in women through diet and lifestyle. *N Engl J Med*. 2000;343(1):16-22. doi:10.1056/NEJM200007063430103.

6. Adams AL, Kessler JI, Deramerian K, et al. Associations between childhood obesity and upper and lower extremity injuries. *Inj Prev*. 2013;19(3):191-197. doi:10.1136/injuryprev-2012-040341.

7. Chaves PH, Ashar B, Guralnik JM, Fried LP. Looking at the relationship between hemoglobin concentration and prevalent mobility difficulty in older women. Should the criteria currently used to define anemia in older people be reevaluated?. *J Am Geriatr Soc*. 2002;50(7):1257-1264. doi:10.1046/j.1532-5415.2002.50313.x.

8. Sherk VD, Palmer IJ, Bemben MG, Bemben DA. Relationships between body composition, muscular strength, and bone mineral density in estrogen-deficient postmenopausal women. *J Clin Densitom*. 2009;12(3):292-298. doi:10.1016/j.jocd.2008.12.002.

9. Hsieh CY, Lee WH, Liu YH, Lu CC, Chen SC, Su HM. Significant impact of body mass index on the relationship between increased white blood cell count and new-onset diabetes. *Int J Med Sci*. 2023;20(3):359-365. Published 2023 Jan 31. doi:10.7150/ijms.80207

10. Duffield JS, Forbes SJ, Constandinou CM, et al. Selective depletion of macrophages reveals distinct, opposing roles during liver injury and repair. *J Clin Invest*. 2005;115(1):56-65. doi:10.1172/JCI22675.

11. Chang XW, Zhang SY, Wang H, et al. Combined value of red blood cell distribution width and global registry of acute coronary events risk score on predicting long-term major adverse cardiac events in STEMI patients undergoing primary PCI. *Oncotarget*. 2018;9(17):13971-13980. Published 2018 Jan 10. doi:10.18632/oncotarget.24128.

12. Pignoli P, Tremoli E, Poli A, Oreste P, Paoletti R. Intimal plus medial thickness of the arterial wall: a direct measurement with ultrasound imaging. *Circulation*. 1986;74(6):1399-1406. doi:10.1161/01.cir.74.6.1399.

13. Pratley RE, Wilson C, Bogardus C. Relation of the white blood cell count to obesity and insulin resistance: effect of race and gender. *Obes Res*. 1995;3(6):563-571. doi:10.1002/j.1550-8528.1995.tb00191.x.

14. Danesh J, Collins R, Appleby P, Peto R. Association of fibrinogen, C-reactive protein, albumin, or leukocyte count with coronary heart disease: meta-analyses of prospective studies. *JAMA*. 1998;279(18):1477-1482. doi:10.1001/jama.279.18.1477.

15. Strimbu K, Tavel JA. What are biomarkers?. *Curr Opin HIV AIDS*. 2010;5(6):463-466. doi:10.1097/COH.0b013e32833ed177.

16. Järvisalo MJ, Harmoinen A, Hakanen M, et al. Elevated serum C-reactive protein levels and early arterial changes in healthy children. *Arterioscler Thromb Vasc Biol*. 2002;22(8):1323-1328. doi:10.1161/01.atv.0000024222.06463.21.

17. Youn JY, Siu KL, Lob HE, Itani H, Harrison DG, Cai H. Role of vascular oxidative stress in obesity and metabolic syndrome. *Diabetes*. 2014;63(7):2344-2355. doi:10.2337/db13-0719.

18. Hotamisligil GS. Inflammation, metaflammation and immunometabolic disorders. *Nature*. 2017;542(7640):177-185. doi:10.1038/nature21363.

19. Minihane AM, Vinoy S, Russell WR, et al. Low-grade inflammation, diet composition and health: current research evidence and its translation. *Br J Nutr*. 2015;114(7):999-1012. doi:10.1017/S0007114515002093.

20. Cushman M, McClure LA, Howard VJ, Jenny NS, Lakoski SG, Howard G. Implications of increased C-reactive protein for cardiovascular risk stratification in black and white men and women in the US. *Clin Chem*. 2009;55(9):1627-1636. doi:10.1373/clinchem.2008.122093.

21. Eriksson P, Kallin B, van 't Hooft FM, Båvenholm P, Hamsten A. Allele-specific increase in basal transcription of the plasminogen-activator inhibitor 1 gene is associated with myocardial infarction. *Proc Natl Acad Sci U S A*. 1995;92(6):1851-1855. doi:10.1073/pnas.92.6.1851.

22. Rana JS, Boekholdt SM, Ridker PM, et al. Differential leucocyte count and the risk of future coronary artery disease in healthy men and women: the EPIC-Norfolk Prospective Population Study. *J Intern Med*. 2007;262(6):678-689. doi:10.1111/j.1365-2796.2007.01864.x.

23. Kullo IJ, Hensrud DD, Allison TG. Comparison of numbers of circulating blood monocytes in men grouped by body mass index (<25, 25 to <30, > or =30). *Am J Cardiol*. 2002;89(12):1441-1443. doi:10.1016/s0002-9149(02)02366-4.

24. Vikram NK, Misra A, Dwivedi M, et al. Correlations of C-reactive protein levels with anthropometric profile, percentage of body fat and lipids in healthy adolescents and young adults in urban North India. *Atherosclerosis*. 2003;168(2):305-313. doi:10.1016/s0021-9150(03)00096-0.

25. Li X, Shen J, Lu Z, Chen M, Fang X, Wang G. High neutrophil-to-lymphocyte ratio is associated with increased carotid artery intima-media thickness in type 2 diabetes. *J Diabetes Investig*. 2017;8(1):101-107. doi:10.1111/jdi.12541

26. Colberg SR. Key Points from the Updated Guidelines on Exercise and Diabetes. *Front Endocrinol (Lausanne)*. 2017;8:33. Published 2017 Feb 20. doi:10.3389/fendo.2017.00033

27. Azab B, Chainani V, Shah N, McGinn JT. Neutrophil-lymphocyte ratio as a predictor of major adverse cardiac events among diabetic population: a 4-year follow-up study. *Angiology*. 2013;64(6):456-465. doi:10.1177/0003319712455216

28. Moxham R, Džavík V, Cairns J, et al. Association of Thrombus Aspiration With Time and Mortality Among Patients With ST-Segment Elevation Myocardial Infarction: A Post Hoc Analysis of the Randomized TOTAL Trial. *JAMA Netw Open*. 2021;4(3):e213505. Published 2021 Mar 1. doi:10.1001/jamanetworkopen.2021.3505

29. Huang YL, Hu ZD, Liu SJ, et al. Prognostic value of red blood cell distribution width for patients with heart failure: a systematic review and meta-analysis of cohort studies. *PLoS One*. 2014;9(8):e104861. Published 2014 Aug 18. doi:10.1371/journal.pone.0104861

30. de Oliveira BR, Bragança MLBM, Batalha MA, et al. Diagnostic performance of body mass index in detection of obesity using different cutoff points for excess body fat. *Nutrition*. 2020;79-80:110950. doi:10.1016/j.nut.2020.110950