

The Relationship between Body Mass Index and Hematological Parameters in Adult Female Students of Peshawar Medical and Dental College

Maryam Tahir¹, Hira Ehsan Khattak^{*2}, Jaleel Kamran³, Muhammad Sameer Hanif⁴, Usama Ghulab⁵, Syed Ahmad Usman⁶

¹Senior Lecturer, Department of Physiology, Watim Medical and Dental College, Rawalpindi.

Email ID: maryam.bds@gmail.com

^{*2}Assistant Professor, Department of Physiology, Watim Medical and Dental College, Rawalpindi

³Associate Professor, Department of Physiology, Watim Medical and Dental College, Rawalpindi

Email ID: drjaleelkamran@ymail.com

⁴Assistant Professor, Department of Physiology, Poonch Medical College, Rawalakot

Email ID: dcetsameer@gmail.com

⁵Demonstrator, Department of Physiology, Watim Medical and Dental College, Rawalpindi

Email ID: minhas_u@hotmail.com

Demonstrator, Department of Physiology, Watim Medical and Dental College, Rawalpindi

Email ID: syedahmadusman@gmail.com

***Corresponding author:**

Hira Ehsan Khattak

Email ID: hira88khattak@gmail.com

Cite this paper as: Maryam Tahir, Hira Ehsan Khattak, Jaleel Kamran, Muhammad Sameer Hanif, Usama Ghulab, Syed Ahmad Usman, (2025) The Relationship between Body Mass Index and Hematological Parameters in Adult Female Students of Peshawar Medical and Dental College. *Journal of Neonatal Surgery*, 14 (32s), 2588-2594.

ABSTRACT

Background: Obesity has become increasingly prevalent globally, associated with chronic inflammation, which contributes to conditions like atherosclerosis and metabolic syndrome. Hematological parameters (such as Hemoglobin, Hematocrit, RBC, WBC, and Platelets) are indicative of physiological status and could potentially correlate with obesity.

Objective: To determine how BMI categories relate to hematological parameters in young female medical and dental students.

Methodology: Study Design: Cross-sectional study conducted at Peshawar Medical and Dental Colleges from July to December 2022. **Population:** Female students aged 18-25 years, totaling 231 participants, chosen by convenience sampling.

Procedure: After informed consent, participants completed a questionnaire, and anthropometric assessments (height and weight) were conducted to calculate BMI. Blood samples were collected and analyzed for hematological parameters.

Statistical Analysis: Data was analyzed using SPSS version 21, with p-values <0.05 considered significant.

Results: The study sample had a mean age of 21.83 ± 1.41 years, with an average height of 165.48 ± 4.88 cm and mean weight of 62.16 ± 8.26 kg. The mean BMI was calculated as 22.78 ± 3.54 kg/m². The mean Hemoglobin and Hematocrit levels were both 12.89 ± 1.15 . The mean Red Blood Cell (RBC) count was 4.42 ± 0.38 , White Blood Cell (WBC) count was 9007.88 ± 1710.79 , and the mean Platelet count was 237476.19 ± 77515.21 . **Conclusion:** Significant differences were found between BMI categories and Hemoglobin (Hb), Hematocrit (HCT), WBC, and Platelets. RBC did not show significant association. Higher BMI is linked to lower levels of Hemoglobin and Hematocrit. Strong positive correlations were observed between BMI and WBC as well as Platelet count.

Keywords: Hemoglobin, hematocrit, obesity, anemia, metabolic syndrome.

1. INTRODUCTION

The rising prevalence of obesity and iron deficiency anemia among adolescents is a significant global health concern, affecting both developed and developing countries. Since 1975, obesity rates have tripled, with 13% of the global population classified as obese, particularly impacting children and adolescents who face increased risks of non-communicable diseases such as diabetes and cardiovascular issues.¹ In low- and middle-income countries, rapid lifestyle changes contribute to this epidemic, with obesity often coexisting with iron deficiency anemia, which affects approximately 78.1% of overweight adolescents.^{2,3} The physiological changes in obese individuals disrupt normal iron metabolism, leading to iron deficiency and complicating health outcomes.⁴ This dual burden of obesity and anemia not only threatens physical health but also has profound implications for mental well-being and quality of life.⁵

Pakistan faces a dual burden of malnutrition, characterized by a significant prevalence of both obesity and anaemia. Approximately 5.1% of the adult population is classified as obese, with urban women particularly affected, highlighting a shift towards non-communicable diseases.⁶ Concurrently, anaemia, primarily iron deficiency anaemia (IDA), affects about 50% of the population, with alarming rates among women of reproductive age and children under five.^{7,8} The condition compromises oxygen transport in the body, leading to reduced aerobic metabolism and energy levels.⁹ Diagnostic parameters such as Mean Corpuscular Volume (MCV) and Mean Corpuscular Hemoglobin (MCH) are crucial for identifying anaemia types, including distinguishing IDA from thalassemia.¹⁰ Addressing these intertwined issues requires comprehensive public health strategies focusing on nutrition education, food security, and targeted interventions to mitigate both obesity and anaemia.^{7,11} Haemoglobin is a conjugated protein that carries oxygen and is found in erythrocytes.

Body Mass Index (BMI) is a prevalent anthropometric tool for assessing obesity, calculated as weight relative to height (kg/m^2), with established categories indicating underweight, normal weight, overweight, and obesity.^{12,13} While BMI is simple and cost-effective, its limitations are significant; it fails to differentiate between fat and muscle mass, and does not account for fat distribution, particularly the health risks associated with abdominal fat.¹⁴ This inadequacy can lead to misclassification of individuals, particularly across different genders, ages, and ethnicities, potentially obscuring true health risks like metabolic syndrome and chronic inflammation.¹⁵ Consequently, there is a growing advocacy for integrating additional measures, such as waist circumference and waist-to-hip ratio, to provide a more comprehensive assessment of obesity-related health risks.¹⁶ Thus, while BMI remains a useful screening tool, its application should be complemented with other metrics to enhance accuracy in health assessments.¹⁷

2. OBJECTIVE:

The objective of this study was to assess the relationship between different BMI categories—underweight, normal, overweight, and obese—and specific hematological parameters, including Hemoglobin, Hematocrit, RBC, WBC, and Platelet counts, among medical and dental students.

3. MATERIALS AND METHODS

This cross-sectional study was conducted at Peshawar Medical College and Peshawar Dental College, Peshawar, focusing on female students aged 18–25 years. Exclusion criteria included those having any cardio-metabolic diseases; undergoing hormonal or antibiotic therapy, steroid therapy, experiencing menstrual irregularities or diagnosed with chronic physical or hematological illnesses, diabetes, or other conditions requiring therapeutic iron supplementation. Additionally, students who were pregnant or lactating, following specific dietary restrictions, or engaged in high-intensity athletic regimens were excluded.

The study duration was approximately two months, allowing adjustments for students' exams and vacations. The sample size was calculated using the online Raosoft sample size calculator. Based on a female student population of 575, with a 50% response rate, 95% confidence interval, and 5% margin of error, the required sample size was determined to be 231 participants. This design ensured adequate representation and statistical reliability for examining the relationship between body mass index and hematological parameters in this population.

Participants completed a detailed questionnaire about their medical history, followed by anthropometric assessments to measure height (to the nearest 0.5 cm) and weight (to the nearest 0.5 kg). Body mass index (BMI) was calculated using the formula $\text{weight (kg)}/\text{height (m)}^2$ and categorized according to WHO guidelines into underweight, normal weight, overweight, and obese groups. Blood samples were collected by a trained female phlebotomist using disposable syringes, tourniquets, and sterile alcohol swabs to ensure proper disinfection. Hematological parameters assessed included Hematocrit, hemoglobin (HB), red blood cells (RBC), white blood cells (WBC), and platelet count. Laboratory analyses were performed using appropriate methods for accurate data collection.

The study utilized tools such as stadiometers, weighing machines, measuring tapes, and standard blood collection equipment. Statistical analysis was conducted using SPSS version 21. Quantitative variables, including age and hematological parameters, were presented as mean $\pm$ standard deviation, while categorical variables, such as BMI categories, were expressed in percentages. The Kruskal-Wallis test assessed associations between categorical variables, while Spearman

correlation evaluated relationships between BMI and hematological parameters. A p-value of less than 0.05 was considered statistically significant. This rigorous methodology ensured comprehensive data collection and reliable analysis to examine the relationship between BMI and hematological parameters in the study population.

4. RESULTS

Out of total 231 study subjects 169(73.2%) were day scholar. 195(84.4%) were normal weight individuals followed by 17(7.4%) Obese, 15(6.5%) overweight and 4(1.7%) underweight.

Table 1: Mean $\pm$ Standard deviation of quantitative study variables

Parameters(n=231)	Mean $\pm$ Std deviation
Age	21.826 $\pm$ 1.406
Height	165.48 $\pm$ 4.88
Weight	62.164 $\pm$ 8.26
BMI	22.78 $\pm$ 3.54
Hemoglobin	12.89 $\pm$ 1.15
Hematocrit	36.5519 $\pm$ 2.67
RBC	4.4245 $\pm$ 0.375
WBC	9007.8788 $\pm$ 1710.79
Platelets	237476.19 $\pm$ 77515.205

Table 1 shows mean value of quantitative study variables. Mean age of study subjects was 21.826 $\pm$ 1.406, mean height 165.48 $\pm$ 4.88 in m², mean weight 62.164 $\pm$ 8.26 in kg, Mean BMI was found to be 22.78 $\pm$ 3.54kg/m². Mean Hemoglobin was 12.89 $\pm$ 1.15 whereas mean Hematocrit came out 36.5519 $\pm$ 2.67. Furthermore, Mean RBC, WBC and Platelets were observed as 4.4245 $\pm$ 0.375, 9007.8788 $\pm$ 1710.79 and 237476.19 $\pm$ 77515.205, respectively.

Table 2: Mean $\pm$ Std deviation of hematological parameters according to BMI category

Parameters (n=231)	Mean $\pm$ Std deviation			
	Under weight	Normal	Overweight	Obese
Hemoglobin	10.7500 $\pm$ 1.108	13.1467 $\pm$.055	11.7333 $\pm$ 0.351	11.5000 $\pm$ 0.493
Hematocrit	31.6500 $\pm$ 1.42	37.0000 $\pm$ 0.161	34.9467 $\pm$ 0.8608	33.9824 $\pm$ 0.857
RBC	4.5 $\pm$ 0.290	4.4127 $\pm$ 0.025	4.3667 $\pm$ 0.0714	4.5824 $\pm$ 0.146
WBC	8625.00 $\pm$ 1546.16	8806.66 $\pm$ 111.486	10066.66 $\pm$ 589.322	10471.7647 $\pm$ 381.66
Platelets	261250.00 $\pm$ 57892.68	227066.6 $\pm$ 4955.8	294200.0000 $\pm$ 25208.12	301235.29 $\pm$ 22559.647

Table 2 shows Mean $\pm$ Std deviation of hematological parameters according to BMI category; Mean hemoglobin distribution for underweight 10.75 $\pm$ 1.108, Normal 13.14 $\pm$ 0.055, over weight 11.73 $\pm$ 0.35 and obese 11.50 $\pm$ 0.49; Mean hematocrit for

underweight 31.65 ± 1.427 , Normal 37.00 ± 0.161 , over weight 34.94 ± 0.86 and obese 33.98 ± 0.85 ; Mean RBC for underweight 4.5 ± 0.290 , Normal 4.412 ± 0.025 , over weight 4.3667 ± 0.0714 and obese 4.5824 ± 0.14634 ; Mean WBC for under weight 8625.00 ± 15.16 , Normal 8806.66 ± 111.48 , over weight 10066.66 ± 589.322 and obese 10471.7647 ± 381.66069 ; and platelets mean count for underweight 261250.00 ± 57892.6808 , Normal 227066.66 ± 4955.85 , over weight 294200.00 ± 25208.124 and obese 301235.29 ± 22559.647 .

Table 3: Distribution of BMI and Hemoglobin among study subjects

Parameters(n=231)		Hemoglobin				Total
		6-8	8.1-10	10.1-12	12.1 and above	
BMI in categories	Under weight	1	1	1	1	4
	Normal weight	0	0	0	195	195
	Overweight	0	2	5	8	15
	Obese	1	4	5	7	17
Total		2	7	11	211	231

Table 3 shows BMI categories and hemoglobin levels distribution and it was reported that 195 normal weight study subjects followed by 8 overweight, 7 obese and 1 underweight; Hence total 211 had 12.1 and above hemoglobin levels.

Table 4: Distribution of BMI and Hematocrit among study subjects

Parameters(n=231)		Hematocrit				Total
		28-31	32-35	36-39	40-43	
BMI in categories	Under weight	1	3	0	0	4
	Normal weight	0	39	130	26	195
	Overweight	3	4	7	1	15
	Obese	3	8	4	2	17
Total		7	54	141	29	231

Table 4 shows BMI categories and Hematocrit distribution and it was reported that 130 normal weight study subjects followed by 7 overweight and 4 obese; Hence total 211 had 36-39 Hematocrit levels.

Table 5: Distribution of BMI and RBC count among study subjects

Parameters(n=231)		RBC				Total
		3-4	4.1-5	5.1-6	6.1 and above	
BMI in categories	Under weight	1	2	1	0	4
	Normal weight	38	157	0	0	195
	Overweight	2	113	0	0	15
	Obese	1	15	0	1	17
Total		42	187	1	1	231

Table 5 shows BMI categories and RBC distribution, and it was reported that 157 normal weight study subjects had RBC in range of 4.1-5; moreover 113 overweight also showed same range of RBC, hence total 187 had RBC count in 4.1-5 range.

Table 6: Distribution of BMI and Platelets among study subjects

Parameters(n=231)		Platelets				Total
		100000-150000	151000-200000	201000-250000	251000 and above	
BMI in categories	Under weight	1	1	0	2	4
	Normal weight	26	66	40	63	195
	Overweight	2	1	4	8	15
	Obese	1	1	3	12	17
Total		30	69	47	85	231

Table 6 shows BMI categories and Platelets distribution and it was reported that total 85 study subjects showed 2.5 lac and above platelets. Among them 63 were normal weighted, 12 obese, 8 overweight and 1 underweight.

5. DISCUSSION

The relationship between body mass index (BMI) and hemoglobin (Hb) levels among female medical students reveals significant variations across studies. In a recent study, mean Hb levels were lowest in underweight students (10.75 g/dL) and highest in those with normal BMI (13.15 g/dL), indicating a significant association ($p < 0.05$) between BMI and Hb levels.¹⁸ This aligns with findings from Jeong et al., 2022 who reported higher Hb levels in normal (13.99 g/dL) and overweight (14.04 g/dL) groups, suggesting population-specific variations.¹⁹ Conversely, S.R Acharya et al. (2024) found no significant differences in Hb across BMI categories, highlighting inconsistencies in the literature.¹⁸ Another study noted a normal mean Hb level of 13.4 g/dL, reinforcing the notion that BMI influences Hb levels, particularly in young females, who are at a higher risk for iron deficiency anemia.²⁰

Hematocrit (HCT) levels were $31.65 \pm 1.42\%$ (underweight), $37.00 \pm 0.16\%$ (normal), $34.94 \pm 0.86\%$ (overweight), and $33.98 \pm 0.85\%$ (obese). A statistically significant association ($p < 0.05$) was observed. Jeong et al. (2022) documented higher HCT levels for normal ($41.91 \pm 0.04\%$), overweight ($42.21 \pm 0.10\%$), and obese ($42.31 \pm 0.10\%$) categories.¹⁹ These differences might stem from demographic and methodological factors. Nazeer (2019) found no significant variation in HCT across BMI groups, partially aligning with the current findings.

RBC levels in this study were 4.5 ± 0.29 (underweight), 4.41 ± 0.03 (normal), 4.37 ± 0.07 (overweight), and 4.58 ± 0.15 (obese), with no significant association with BMI ($p = 0.203$). Jeong et al. (2022) observed higher RBC counts for normal (4.82 ± 0.01), overweight (4.88 ± 0.01), and obese (4.90 ± 0.01) groups, which showed a statistically significant relationship ($p < 0.001$). Singh et al. (2021) similarly reported no significant variation in RBC levels among BMI categories, consistent with the present study.²¹

WBC levels increased with BMI, ranging from 8625.0 ± 1546.16 (underweight) to 10471.76 ± 381.66 (obese), reflecting a positive correlation ($p = 0.004$). Similarly, platelet counts rose with BMI, showing a statistically significant relationship ($p = 0.009$). Jeong et al. (2022) documented similar trends, with WBC and platelet counts positively correlated with BMI, highlighting systemic inflammatory responses associated with higher BMI. Nazeer (2019) also reported a direct relationship between BMI and WBC counts, emphasizing concordance with the current findings.^{19,22}

This study found an inverse correlation between BMI and hemoglobin (Spearman's rho -0.078) and hematocrit (-0.001), indicating that higher BMI is associated with reduced levels of these parameters. Haidari et al. (2020) reported similar findings, with hemoglobin showing a negative correlation with BMI ($r = -0.155$).²³ In contrast, Jeong et al. (2022) observed a positive correlation between BMI and Hb ($r = 0.042$) and HCT ($r = 0.067$), underscoring population-specific variability.¹⁹

RBC levels showed a weak positive correlation with BMI (Spearman's rho 0.053), though this association was not statistically significant. Similar findings by Singh et al. (2021) and Nazeer (2019) reported no significant RBC variation among BMI groups.^{21,22} However, Jeong et al. (2022) reported a positive correlation ($r = 0.109$) and statistically significant differences, suggesting potential variability in study populations and methodologies.¹⁹

Conversely, WBC and platelet counts were positively correlated with BMI, aligning with findings by Jeong et al. (2022), who observed significant positive correlations (WBC: $r = 0.222$; platelets: $r = 0.180$).¹⁹ This reflects systemic inflammatory and hematopoietic changes linked to increased adiposity.

REFERENCES

- [1] Alshwaiyat NM, Ahmad A, Wan Hassan WMR, Al-Jamal HAN. Association between obesity and iron deficiency (Review). *Exp Ther Med*. 2021 Nov;22(5):1268.
- [2] A National Survey of the Prevalence of Anemia and Obesity in Indian School Children - PMC. 2022 Oct; Available from: <https://pmc.ncbi.nlm.nih.gov/articles/PMC9529649/>
- [3] YalemWork Getnet SG. iron deficiency anemia and its association with overweight and obesity among adolescents in Addis Ababa, Ethiopia. 2023 Sep 22; Available from: <https://etd.aau.edu.et/items/d85baeb2-2d41-4978-9bb7-4e79ef6b68e6>
- [4] Tan X, Tan PY, Gong YY, Moore JB. Overnutrition is a risk factor for iron, but not for zinc or vitamin A deficiency in children and young people: a systematic review and meta-analysis. *BMJ Glob Health* [Internet]. 2024 Apr 9 [cited 2025 Jun 14];9(4). Available from: <https://gh.bmj.com/content/9/4/e015135>
- [5] Hamed M, Zaghloul A, Halawani SH, Fatani BA, Alshareef B, Almalki A, et al. Prevalence of Overweight/Obesity Associated With Anemia Among Female Medical Students at Umm Al-Qura University in Makkah, Saudi Arabia: A Cross-Sectional Study. *Cureus*. 2024 Mar;16(3):e57081.
- [6] Asif M, Aslam M, Altaf S, Atif S, Majid A. Prevalence and Sociodemographic Factors of Overweight and Obesity among Pakistani Adults. *J Obes Metab Syndr*. 2020 Mar 30;29(1):58–66.
- [7] Mahar B, Shah T, Shaikh K, Shaikh SN, Uqaili AA, Memon KN, et al. Uncovering the hidden health burden: a systematic review and meta-analysis of iron deficiency anemia among adolescents, and pregnant women in Pakistan. *J Health Popul Nutr*. 2024 Sep 17;43(1):149.
- [8] Ali SA, Abbasi Z, Shahid B, Moin G, Hambidge KM, Krebs NF, et al. Prevalence and determinants of anemia among women of reproductive age in Thatta Pakistan: Findings from a cross-sectional study. *PLoS One*. 2020;15(9):e0239320.
- [9] Factors And Determinants Associated With Prevalence Of Anaemia In Adults In Karachi, Pakistan - PubMed [Internet]. [cited 2025 May 25]. Available from: <https://pubmed.ncbi.nlm.nih.gov/38013522/>
- [10] Channar HB, Laghari ZA, Samo AA, Ujjan ID. Factors And Determinants Associated With Prevalence Of Anaemia In Adults In Karachi, Pakistan. *J Pak Med Assoc*. 2023 Nov;73(11):2165–70.
- [11] Kashif M, Nasreen GE, Shahbaz MN, Imran MA, Mujahid AY, Rauf MA. Frequency of Anemia among Primary School Children in Lahore, Pakistan: A Cross-Sectional Study. *Pakistan Journal of Medical & Health Sciences*. 2025 Feb 1;19(1):4–8.
- [12] National Academies of Sciences E, Division H and M, Board F and N, Solutions R on O, Callahan EA. The Science, Strengths, and Limitations of Body Mass Index. In: *Translating Knowledge of Foundational Drivers of Obesity into Practice: Proceedings of a Workshop Series* [Internet]. National Academies Press (US); 2023 [cited 2025 May 25]. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK594362/>
- [13] Carrión-Martínez A, Buckley BJR, Orenes-Piñero E, Marín F, Lip GYH, Rivera-Caravaca JM. Anthropometric Measures and Risk of Cardiovascular Disease: Is there an Opportunity for Non-Traditional Anthropometric Assessment? A Review. *Rev Cardiovasc Med*. 2022 Dec;23(12):414.
- [14] Bray GA. Beyond BMI. *Nutrients*. 2023 May 10;15(10):2254.
- [15] Katherine Sweatt KS. Strengths and Limitations of BMI in the Diagnosis of Obesity: What is the Path Forward? | *Current Obesity Reports* [Internet]. 2023. Available from: <https://link.springer.com/article/10.1007/s13679-024-00580-1>
- [16] Sergi TE, Bode KB, Hildebrand DA, Dawes JJ, Joyce JM. Relationship between Body Mass Index and Health and Occupational Performance among Law Enforcement Officers, Firefighters, and Military Personnel: A Systematic Review. *Current Developments in Nutrition*. 2023 Jan 1;7(1):100020.
- [17] Khanna D, Peltzer C, Kahar P, Parmar MS. Body Mass Index (BMI): A Screening Tool Analysis. *Cureus*. 14(2):e22119.
- [18] Acharya SR, Timilsina D, Acharya S. Association between blood hemoglobin levels, anemia, and body mass index in children and women of Myanmar: findings from a nationally representative health study. *Sci Rep*. 2024 Dec 30;14:32020.
- [19] Jeong HR, Lee HS, Shim YS, Hwang JS. Positive Associations between Body Mass Index and Hematological Parameters, Including RBCs, WBCs, and Platelet Counts, in Korean Children and Adolescents. *Children (Basel)*. 2022 Jan 14;9(1):109.
- [20] Adib Rad H, Sefidgar SAA, Tamadoni A, Sedaghat S, Bakouei F, Bijani A, et al. Obesity and iron-deficiency anemia in women of reproductive age in northern Iran. *J Educ Health Promot*. 2019;8:115.

- [21] Singh P, Singh SK, Reddy VK, Sharma S, Chandra S, Vijay P. A Study on Association of Age, Gender, and Body Mass Index with Hematological Parameters. *Journal of Indian Association of Public Health Dentistry*. 2021 Jun;19(2):109.
 - [22] Nazeer DS. Evaluation of haematological profile and body mass index in adults: Observational assessment. *Pharma Innovation*. 2019;8(10):214–6.
 - [23] Haidari F, Abiri B, Haghighizadeh MH, Kayedani GA, Birgani NK. Association of Hematological Parameters with Obesity- Induced Inflammation Among Young Females in Ahvaz, South-West of Iran. *Int J Prev Med*. 2020 Apr 30;11:55.
-

