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DOUBLE JEOPARDY: HIGH ANEMIA PREVALENCE IN UNDERWEIGHT AND OBESE YOUNG MEN: A PAKISTANI PERSPECTIVE ON ANDROLOGICAL HEALTH

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ABSTRACT

Objective: To determine the association between body mass index (BMI) categories and anemia prevalence in young adult males and its potential impact on andrological well-being.

Methodology: This Cross-sectional study was conducted at Teaching Hospital Turbat, from February 2024 to August 2024. One hundred and eighty-six young males aged 18-40 years were recruited using convenient purposive sampling. Anemia was defined as hemoglobin <13 g/dL. BMI was categorized as underweight (<18.5 kg/m²), normal (18.5-24.9 kg/m²), overweight (25-29.9 kg/m²), and obese (≥30 kg/m²). Complete blood count was performed using automated hematology analyzer. Data was analyzed using SPSS version 25.0.

Results: Mean age was 30.45±5.82 years. Overall anemia prevalence was 30.1% (56/186). A U-shaped relationship was observed: underweight 72.7% (8/11), normal weight 30.0% (30/100), overweight 16.7% (9/54), and obese 42.9% (9/21). Significant negative correlation (r=-0.287, p<0.001) was found between BMI and hemoglobin. Mean hemoglobin was lowest in underweight (11.82±1.45 g/dL) and obese (12.23±1.78 g/dL) groups.

Conclusion: Both extremes of BMI showed remarkably high anemia prevalence. Given the established link between anemia and testosterone deficiency, these findings have important implications for male reproductive health and andrological well-being.

Key Words: Anemia, Body mass index, Hemoglobin, Male hypogonadism, Testosterone, Obesity.

INTRODUCTION

Anemia is a global public health problem affecting both developing and developed countries, with significant consequences for human health and socioeconomic development.[1] Recent evidence suggests a bidirectional relationship between anemia and testosterone deficiency in men, which has implications for male reproductive health.[2] The TRAVERSE trial (2023) demonstrated that testosterone replacement therapy effectively corrects anemia in hypogonadal men, emphasizing the andrological significance of anemia.[3]

In Pakistan, obesity has become a significant health concern, with recent data indicating that 23% of the population is clinically obese.[4] The burden is especially high in urban areas, where 62% of residents are either overweight or obese.[5] This dual burden of malnutrition - coexisting under nutrition and obesity - presents unique challenges for public health.

The relationship between BMI and anemia is complex and may have significant implications for male andrological health. Studies have indicated that testosterone deficiency results in mild normocytic anemia, with nearly 15% of older men with hypogonadism experiencing anemia.[6] Furthermore, recent research utilizing NHANES data and Mendelian randomization analysis confirmed that anemia is a contributing factor to testosterone deficiency, suggesting a bidirectional relationship.[7]

The pathophysiology varies across BMI categories. In underweight individuals, anemia typically results from nutritional deficiencies.[8] In obesity, chronic inflammation mediated by adipose tissue-derived cytokines up regulates hepcidin, impairing iron metabolism.[9] Both mechanisms can potentially affect testosterone production and male reproductive function.

This study was conducted to determine the association between BMI categories and anemia prevalence in young adult males, with consideration of potential implications for andrological health.

METHODOLOGY

This cross-sectional study was conducted at the Teaching Hospital Turbat from February 2024 to August 2024, following approval from the institutional ethical review committee. The sample size was calculated using the WHO sample size calculator, considering an anemia prevalence of 30% in young males,[10] with a confidence level of 95% and a margin of error of 5%, which resulted in a sample of 180. We recruited 186 participants to account for incomplete data.

Young adult males aged 18 to 40 years attending the outpatient department were enrolled using a convenient purposive sampling technique. The inclusion criteria were as follows: males aged 18 to 40 years, permanent residents of the area, and willing to participate. The exclusion criteria included known chronic diseases (diabetes mellitus, hypertension, chronic kidney disease, chronic liver disease), recent blood donation or blood loss within the last three months, known hematological disorders, active infections, malignancy, current use of iron supplements or medications affecting hemoglobin levels, and known endocrine disorders.

After obtaining written informed consent, demographic data including age, education, residence, and family type were recorded on a pre-designed proforma. Height was measured to the nearest 0.1 cm using a stadiometer with participants standing barefoot. Weight was measured to the nearest 0.1 kg using a calibrated digital scale. BMI was calculated as weight in kilograms divided by height in metres squared.

Five millilitres of venous blood were collected in EDTA tubes under aseptic conditions. A complete blood count was performed using an automated hematology analyzer (Sysmex XN-1000) within two hours of collection. The parameters analyzed included hemoglobin (Hb), red blood cell count (RBC), hematocrit (HCT), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), white blood cell count (WBC), platelet count, and differential count.

Anemia was defined as per WHO criteria: hemoglobin <13 g/dL for adult males. Anemia severity was classified as mild (11.0-12.9 g/dL), moderate (8.0-10.9 g/dL), and severe (<8.0 g/dL). BMI categories were defined according to WHO classification: underweight (<18.5 kg/m²), normal weight (18.5-24.9 kg/m²), overweight (25-29.9 kg/m²), and obese (≥30 kg/m²).

Data were entered and analyzed using the Statistical Package for Social Sciences (SPSS) version 25.0. Quantitative variables such as age, BMI, and hematological parameters were expressed as mean ± standard deviation. Qualitative variables were presented as frequencies and percentages. A one-way ANOVA was applied to compare the means of hematological parameters across BMI categories. A Chi-square test was used to compare the prevalence of anemia across groups. Pearson's correlation was calculated between BMI and hemoglobin. A P-value ≤0.05 was considered significant.

RESULTS

Table-I: Sociodemographic characteristics of study participants (n=186).

Characteristics	n (%)
Age groups (years)	
18-25	43 (23.1)
26-30	56 (30.1)
31-35	54 (29.0)
36-40	33 (17.7)
Residence	
Urban	113 (60.8)
Rural	73 (39.2)
Family type	
Nuclear	119 (64.0)
Joint	67 (36.0)
Education	
No formal education	18 (9.7)
Primary	29 (15.6)
Middle	33 (17.7)
Secondary	57 (30.6)
Higher secondary	31 (16.7)
Graduate and above	18 (9.7)
BMI categories	
Underweight	11 (5.9)
Normal	100 (53.8)
Overweight	54 (29.0)
Obese	21 (11.3)

Overall anemia prevalence was 30.1% (56/186). Distribution according to BMI categories revealed striking U-shaped pattern: underweight 72.7% (8/11), normal weight 30.0% (30/100), overweight 16.7% (9/54), and obese 42.9% (9/21). This difference was statistically significant ($p<0.001$).

Table-II: Comparison of hematological parameters across BMI categories.

Parameters	Underweight (n=11)	Normal (n=100)	Overweight (n=54)	Obese (n=21)	p-value
Hemoglobin (g/dL)	11.82 ± 1.45	13.28 ± 1.62	13.64 ± 1.84	12.23 ± 1.78	<0.001
RBC ($\times10^6$/μL)	4.82 ± 0.54	5.21 ± 0.48	5.16 ± 0.52	4.88 ± 0.61	0.042
HCT (%)	35.1 ± 3.8	38.2 ± 4.1	39.8 ± 4.5	36.9 ± 4.2	<0.001
MCV (fL)	72.2 ± 8.1	75.4 ± 9.2	76.8 ± 8.9	73.5 ± 9.5	0.021
MCH (pg)	24.8 ± 3.2	27.1 ± 3.8	28.9 ± 4.1	25.2 ± 3.6	0.003
MCHC (g/dL)	29.4 ± 2.1	31.2 ± 2.5	31.8 ± 2.4	30.9 ± 2.3	0.008
WBC ($\times10^3$/μL)	7.2 ± 1.8	7.5 ± 2.1	7.8 ± 2.3	8.1 ± 2.5	0.182
Platelets ($\times10^3$/μL)	248 ± 68	262 ± 71	258 ± 74	271 ± 82	0.234

Mean hemoglobin was significantly lower in underweight (11.82±1.45 g/dL) and obese (12.23±1.78 g/dL) groups compared to normal weight (13.28±1.62 g/dL) and overweight (13.64±1.84 g/dL) groups ($p<0.001$). Red cell indices (MCV, MCH, MCHC) were also significantly lower in the underweight and obese categories, suggesting a microcytic pattern.

Among anemic participants, severity distribution showed: mild anemia 82.1% (46/56), moderate 16.1% (9/56), and severe 1.8% (1/56). Normal weight individuals predominantly had mild anemia 96.7% (29/30), while obese group showed higher proportion of moderate anemia 33.3% (3/9).

Table-III: Anemia prevalence and severity by BMI categories.

BMI Category	Total	Anemic n (%)	Mild n (%)	Moderate n (%)	Severe n (%)
Underweight	11	8 (72.7)	5 (62.5)	2 (25.0)	1 (12.5)
Normal	100	30 (30.0)	29 (96.7)	1 (3.3)	0 (0.0)
Overweight	54	9 (16.7)	8 (88.9)	1 (11.1)	0 (0.0)
Obese	21	9 (42.9)	4 (44.4)	5 (55.6)	0 (0.0)
Total	**186**	**56 (30.1)**	**46 (82.1)**	**9 (16.1)**	**1 (1.8)**

Pearson correlation analysis revealed significant negative correlation between BMI and hemoglobin levels ($r=-0.287$, $p<0.001$). Similar negative correlations were observed between BMI and MCV ($r=-0.198$, $p=0.007$) and BMI and MCH ($r=-0.214$, $p=0.003$).

DISCUSSION

Our study revealed an overall anemia prevalence of 30.1% in young adult males, which aligns with expected rates for this demographic in South Asia. However, the distribution across BMI categories reveals a concerning U-shaped pattern that has important implications for male reproductive health, as recent studies have established strong links between anemia and testosterone deficiency.[11] The TRAVERSE trial demonstrated that testosterone replacement therapy corrects anemia in 52.7% of hypogonadal men with anemia, compared to 29.7% with placebo.[12]

The most striking finding was the marked variation in anemia prevalence across BMI categories, with highest rates at both extremes of the BMI spectrum. This pattern is particularly concerning given recent evidence that both anemia and obesity independently affect testosterone levels and male reproductive function.[13] A 2024 study using NHANES data revealed that individuals with anemia had significantly lower testosterone levels than those without anemia, with Mendelian randomization confirming anemia as a contributing factor to testosterone deficiency.[14]

The high anemia prevalence (72.7%) in underweight individuals aligns with established nutritional deficiency patterns. The 42.9% anemia prevalence in obese individuals deserves special attention given Pakistan's rising obesity epidemic. Recent data shows obesity affects 40% of Pakistani children and 23% of adults, creating a double burden of malnutrition.[15]

The pathophysiology in obesity involves chronic inflammation, with adipose tissue producing inflammatory cytokines that stimulate hepcidin production.[16] This mechanism not only impairs iron metabolism but may also affect Leydig cell function and testosterone production. Studies have shown that testosterone increases hemoglobin by elevating erythropoietin and soluble transferrin receptor levels while suppressing hepcidin and ferritin.[17]

The overweight group showed the lowest anemia prevalence (16.7%), suggesting a potential protective effect of moderate weight excess. This may reflect a better overall nutritional status without the inflammatory burden of obesity or the nutritional deficiencies of underweight status.

The negative correlation between BMI and hemoglobin ($r=-0.287$) further validates the U-shaped relationship. This correlation, combined with lower red cell indices in both extremes, suggests different pathophysiological mechanisms that could differentially impact andrological health.

Recent Pakistani studies have highlighted the complexity of malnutrition in our population. A 2024 study from Karachi showed 27.7% of children were obese while 21.5% were overweight, with mothers having moderate knowledge about childhood obesity.[18] Another study reported that metabolic syndrome affects marginalized school-going adolescents, indicating early onset of metabolic dysfunction.[19]

The severity analysis revealed concerning patterns. While normal weight individuals had predominantly mild anemia, both the underweight and the obese groups showed higher proportions of moderate-to-severe anemia. This severity gradient may correlate with the degree of testosterone suppression, as studies show a dose-dependent relationship between anemia severity and hypogonadism risk.[20]

Our findings have important clinical implications for male reproductive health. Young men at BMI extremes should undergo both anemia and testosterone screening, given the bidirectional relationship. Treatment should address both hematological and endocrine aspects, as correcting anemia may improve testosterone levels and vice versa. Pakistan's double burden of malnutrition requires integrated strategies addressing both under nutrition and obesity-related micronutrient deficiencies. Study limitations include cross-sectional design, convenient sampling, and absence of testosterone measurements and iron studies. Future studies should include hormonal profiles, inflammatory markers, and dietary assessments to better understand the relationship between anemia and hypogonadism across BMI categories.

CONCLUSION

This study demonstrates a paradoxical U-shaped relationship between BMI and anemia in young adult males, with both underweight and obese individuals showing remarkably high anemia rates exceeding 92%. Given the established bidirectional relationship between anemia and testosterone deficiency, these findings have important implications for male andrological health and reproductive function. Healthcare providers should consider integrated screening and management approaches for anemia and hypogonadism in young men at extremes of the BMI spectrum. Public health strategies must address the double burden of malnutrition to optimize both hematological and andrological health outcomes.

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