Original Article

Evaluating Significant Interconnection of Body Mass Index and Body Fat with Hemoglobin Concentration in Young Adult Females

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Abstract

Background: Iron deficiency anaemia is a Global Health risk among Young women. In obese young individuals, the adipose tissue is characterised by macrophage infiltration and associated inflammation, resulting in disruption of iron Homeostasis, further decreasing haemoglobin concentration. The study aims to assess the relationships between haemoglobin, body mass index, and Body fat in young adult Females. **Material and Methods:** Eighty young adults, aged 18-35 Years, from the medical college& hospital participated in this observational study. Inclusion criteria: Young adult females aged 18-35 years. Exclusion criteria-H/O Cardiovascular disease/Bleeding disorders/Recent Blood transfusion/Diabetes mellitus/Hypertension/Chronic kidney disease/Pregnancy. Informed written consent was obtained. The following parameters were measured: height in cm (stadiometer), Weight in kg (Digital weighing scale), and Body fat in % (Electronic Digital Body fat analyser). BMI is calculated according to the WHO criteria—haemoglobin in g/dL (Automated analyser). Values of Haemoglobin<12 gm% are suggestive of anaemia. Statistical analysis was performed using Pearson's correlation to determine if there is a significant correlation between Hb and the measured parameters: Height, Weight, BMI, and Body fat percentage. **Results:** In our study, overweight individuals are around 37.5 % have significantly lower haemoglobin concentration. Haemoglobin levels were significantly decreased in obese individuals($p<0.000$). A negative correlation is observed between Haemoglobin and BMI ($r = -0.965$, $p < 0.001$) & between Haemoglobin and Body fat percentage ($r = -0.678$, $p < 0.001$). **Conclusion:** An increase in Body fat percentage is an Indicator of a Low Haemoglobin Level. In our study, obese females showed a significant negative correlation between haemoglobin levels and BMI, as well as body fat Percentage.

Keywords: Haemoglobin, Body mass index, Body fat, young women.

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Introduction

Iron deficiency anaemia is the most common type of nutritional anaemia, primarily caused by iron deficiency, and it is a significant public health concern. Individuals are at greater risk of Iron deficiency during Adolescence or early adulthood. Nutritional requirements increase during a Growth spurt in this most vulnerable period.[1] Prevalence of anaemia in adolescent girls is 56% according to the data provided by the National Family Health Survey 3(NFHS 3).[2] Although Multiple tests are available for the measurement of iron status, haemoglobin concentration is the absolute indicator to diagnose and to estimate the severity of iron deficiency.[3]

Obesity, the "New World syndrome", is the predominant first wave, adding to the "Weight of the Nation", doomed to be grouped under "Metabolic syndrome" along with other non-communicable Diseases like Diabetes, Hypertension, Dyslipidemia.[4] caused mainly due to an imbalance in the interaction of two sets of neurons, the Agouti-related protein (AGRP) and (NPY) neurons in the arcuate nucleus of the hypothalamus, leading to altered physiology of Energy Homeostasis, resulting in excessive food intake and minimal energy expenditure.[5]

Compared to the rest of the world, obesity in India is a "Thin Fat Indian phenotype". BMI –Body mass index is the ratio of Weight to height squared (Weight (Kg)/Height (m2)). It is an important indicator of obesity. A higher BMI does not always reflect increased body fat, as excess weight can also be due to increased muscle mass. A new alternative to BMI is the Body Adiposity Index (hip circumference/height1.5 -18). The body adiposity index is strongly correlated with adiposity compared to BMI.BAI-BF% is often used to mirror Body fat percentage for adult men and women of various ethnicities.[6,7]

Iron is the key component of oxygen-carrying proteins, and its tight regulation is essential for normal cellular metabolism. In response to obesity-related inflammation, adipose-derived cytokines such as IL-6 and Leptin were produced, which activate gene transcription of hepcidin. Hepcidin, being a regulator of systemic iron status, controls the activity of iron exporter Ferroportin-1. Hepcidin mRNA expression is expected

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to be higher in visceral and subcutaneous adipose tissue in obese females, leading to the downregulation of ferroportin-1. This results in increased iron sequestration and reduced iron bioavailability, ultimately causing dysregulation of iron metabolism in the context of obesity. In centrally obese adolescents, Inflammatory Biomarkers such as C-reactive proteins are associated inversely with serum iron.[8,9]

Aim & objective:

The study aims to elucidate the relationship between haemoglobin and body mass index, as well as body fat, in young adult females.

Materials and Methods

Eighty female subjects aged 18-35 participated in this observational study. This study was conducted at medical college & Hospital from June 2020 to December 2020. Informed written consent was obtained from all the participants. Detailed history taking was done, and women with a history of cardiovascular disease, Diabetes mellitus, bleeding disorders, Chronic infection, chronic illness, Pregnancy, abortion, Recent blood donation, and chronic kidney disease were excluded from the study.

Data Collection: The anthropometric measurements, such as height and weight, were taken. Height in cm was measured using a stadiometer, with the subject standing against it barefoot, without a cap or headgear, and with the heels, gluteus, and occiput touching it. Weight in kg is measured by using a Digital weighing scale, with light clothing and without shoes.[10] Body mass index is calculated and classified according to WHO criteria.[11]

Body mass index=Weight in (kg)/Height in m^2.

Table 1(a): Cut off values of Body mass index (BMI) (11)

Classification	Bmi-asian cut off	Classification	Bmi-european cut off
Underweight	<18.5	UNDERWEIGHT	<18.5
Normal range	18.5-24.9	NORMAL RANGE	18.5-24.9
Overweight	>23	OVERWEIGHT	>25
At risk	23-24.9	PREOBESE	25-29.9
Obese I	25-29.9	OBESE I	30-34.9
Obese II	>30	OBESE II	35-39.9
		OBESE III	>40

Body fat is analysed using an electronic body fat analyser. The following parameters of an individual are set on the analysing machine scale, and the participants of the study were advised to stand on the weighing platform gently with bare feet. The level of percentage of body fat, muscle mass, and hydration was shown on the screen.

Table 1(b): Assessment chart of Body fat percentage in females.

Body fat percentage		Body fat percentage	
Age <30		Age>30	
Percentage	Status	Percentage	Status
4.0-16.0%	Too lean	4.0-20.0%	Too lean
16.1-20.5%	Lean	20.1-25.0%	Lean
20.6-25.0%	Normal	25.1-30.0%	Normal
25.1-30.5%	Fat	30.1-35.0%	Fat
30.6-60.0%	Too fat	35.1-60.0%	Too fat

Hemoglobin is measured by using automated analyser Beckman coulter counter. The normal reference range of haemoglobin levels in young women is 12-14g%. A value of haemoglobin < 12 g/dL is suggestive of anaemia.

Statistical analysis: Data analysis was done using IBM SPSS (Statistical package for social science) software version 16.0 for windows 10.0. Data were presented in mean and standard deviation. Correlation between Hemoglobin and other anthropometric parameters including Body fat were done by using Pearson's correlation coefficient. One-way ANOVA was used to compare the BMI subgroups with Body fat percentage and haemoglobin levels in young women. The confidence interval is set at 95% and a p-value ($p < 0.005$) is considered significant.

Results

Table 2: Descriptive statistics of the Age, Anthropometric parameters and Hemoglobin concentration of the participants in the study.

	Total (n=80)			
	Min.	Max.	Mean	S.D
Age(years)	18	35	26.71	4.925
Height(Cm)	150	160	154.90	3.009
Weight(Kg)	46	75	59.99	9.700
BMI(Kg/m2)	18.59	33.33	25.0664	4.07464
Body fat %	21	51	27.40	7.038
SBP(mm Hg)	100	140	118.00	11.735

DBP(mm Hg)	60	90	76.50	7.309
Hemoglobin(g%)	7.30	13.50	10.4463	1.91760

Table 3: Total percentage ofBMI grading in the study participants.

GRADING OF BMI	Total		P value
	N	%	
<18.5	0	0	0.000<0.01 Significant
18.5-24.9	40	50.0%	
25.0-29.9	30	37.5%	
30-34.9	10	12.5%	
Total	80	100.0%	

Table 4: Correlation between Hemoglobin versus Anthropometric parameters including Body fat and Hemoglobin concentration

Correlation(n-80)		
Parameters	**r value**	**p value**
Age(years)	-0.078	0.492
Height(Cm)	0.043	0.705
Weight(Kg)	-0.967	0.000**
BMI(Kg/m2)	-0.965	0.000**
Body fat %	-0.678	0.000**
SBP(mm Hg)	0.031	0.784
DBP(mm Hg)	0.025	0.824

** Correlation is significant at the 0.01 level / * Correlation is significant at the 0.05 level.

Table 5: Comparision of variables based on BMI subgroups using one-way ANOVA

Parameters	n	Normal(18.5-24.9)	Overweight(25.0-29.9)	Obese Grade I(30-34.9)	F Value	PValue
		MEAN ±SD (n-40)	MEAN ±SD(n-30)	MEAN ±SD(n-10)		
SBP(mm Hg)	80	118.00± 11.810	118.33± 12.058	117.00 ±11.595	0.047	0.954
DBP(mm Hg)	80	76.50± 7.355	76.67± 7.112	76.00 ±8.433	0.030	0.970
Height(Cm)	80	154.98± 3.101	155.53 ±2.921	152.70± 1.889	3.568	0.033*
Weight(Kg)	80	50.98± 2.931	67.70± 3.583	72.90 ±1.663	352.349	0.000**
BMI(Kg/m2)	80	21.3257±1.19683	27.9864± 1.28496	31.2697±.91618	415.201	0.000**
Body fat %	80	23.09± 2.216	27.74± 1.977	43.66 ±4.915	249.917	0.000**
Hemoglobin(g%)	80	12.2100± .55875	8.7900± .94736	8.3600± .47656	239.389	0.000**

** significant at the 0.01 level /* significant at the 0.05 level

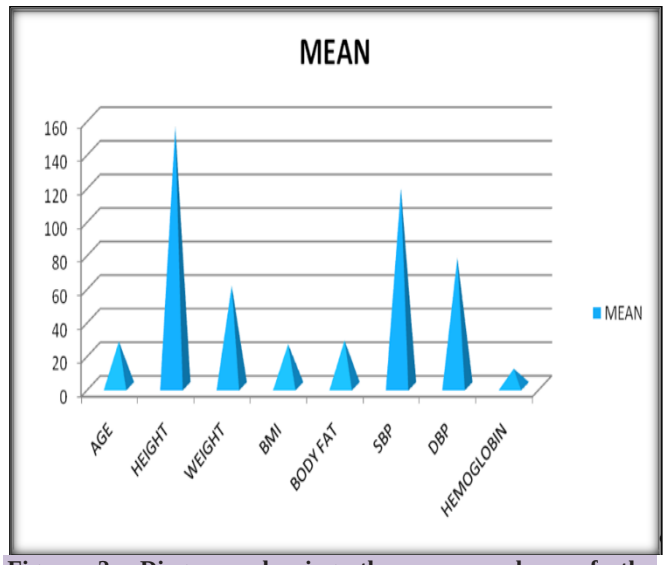


Figure 2: Diagram showing the mean values of the anthropometric parameters and Hemoglobin concentration.

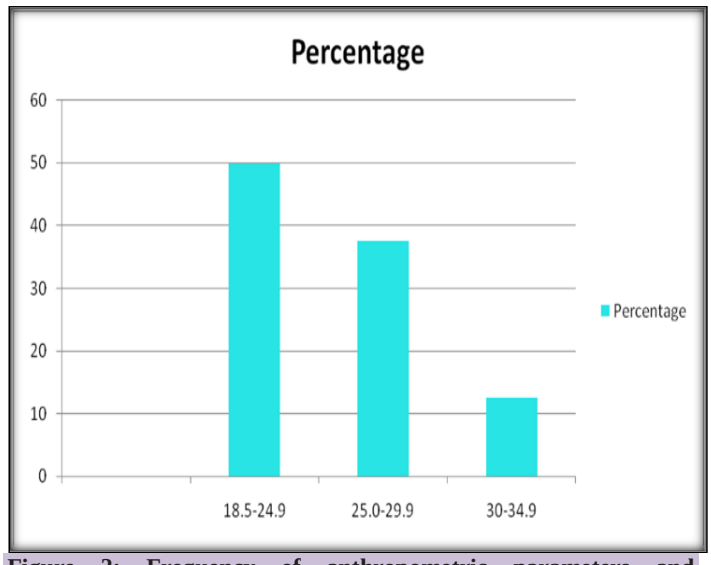


Figure 2: Frequency of anthropometric parameters and Hemoglobin concentration

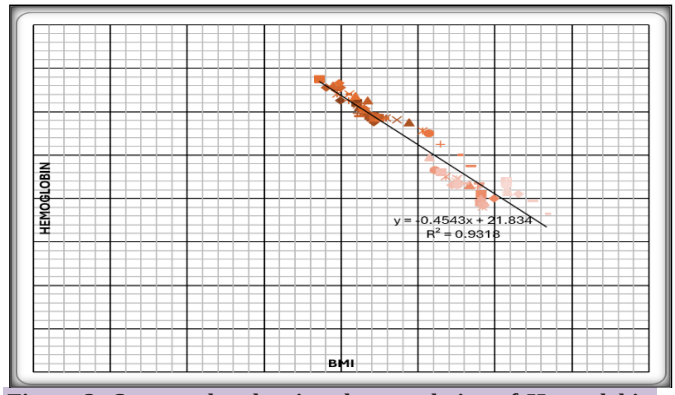


Figure 3: Scatter plot showing the correlation of Hemoglobin with Body mass index

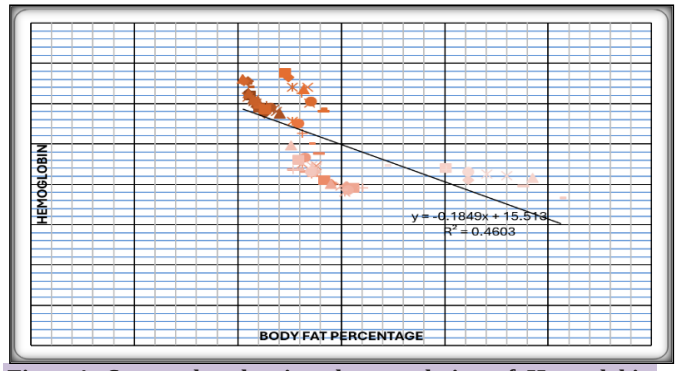


Figure4: Scatterplot showing the correlation of Hemoglobin with Body fat percentage.

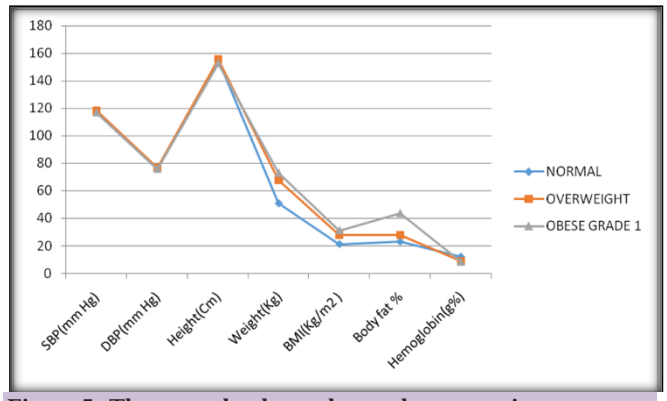


Figure 5: These graphs shows that anthropometric parameters (Height, Weight, Body mass index, Body fat percentage) and Hemoglobin concentration compared with the BMI subgroups showed a statistically significant difference (p<0.000) in the participants.

Discussion

This observational study was conducted in 80 young women who were age-matched and had similar anthropometric parameters, including Body fat percentage. Hemoglobin concentrations were measured. The subjects were classified according to BMI into Normal weight, overweight, and obese individuals. The association between haemoglobin, body mass index, and Body fat percentage was assessed.

In our study, we observed that the overall haemoglobin concentration has a mean value of 10.4463. In our research, it is evident that Haemoglobin has an inverse association with BMI and Body fat percentage. The correlation between Hemoglobin and Weight, showed a highly significant negative correlation. Similarly, a negative correlation was observed between Hemoglobin and Body mass index indicating that Obesity which is been indicated by Body mass index (BMI) is found to have a negative impact on the levels of Hemoglobin in young adult females. Another variable the Body Fat was correlated using Pearson's correlation with Hemoglobinit showed a negative correlation proving to be statistically significant.BMI initially showed a negative correlation (r = -0.965), and Body fat percentage also showed a correlation in the negative range (r = -0.678), as given in Table 4. Our study shows that assessing the rough status of haemoglobin in an adult female can be considered a better parameter than body fat.

Upon comparing various parameters with the BMI subgroups as shown in Table 5, we can appreciate that Height and weight, when compared with BMI subgroups, showed statistical significance, indicating that BMI is the most standard method for evaluating the extent of obesity. Other variables, such as Body Mass Index and Body Fat percentage, also proved to have statistical significance in comparison with BMI subgroups.

In our study, we found that the Haemoglobin concentration in overweight individuals was significantly lower compared to those with a normal weight range, as shown in Table 4. Similarly, the individuals who were classified as obese grade I also had lower Haemoglobin levels (mean-8.3600) compared to those weighing in the normal weight range.

Body fat percentage is significantly higher in individuals with obese grade I, indicating that Body fat percentage is a reliable tool to predict metabolic syndrome, such as Obesity. Compared to individuals with a normal weight range, the Body fat percentage in overweight individuals is found to be higher.

In our study, we found that overweight individuals are around 37.5%, which indicates that overweight individuals have significantly lower haemoglobin concentrations. These results are supportive of the survey conducted by Ursala Viana Bagni et al., which found that overweight individuals present with a significant reduction in haemoglobin concentration compared to those who are not overweight, indicating impairment of iron metabolism, which brings about a negative repercussion, especially during adolescence.[12]

In our study, we found that the concentration of haematological iron markers, like haemoglobin, was profoundly lower in overweight and obese individuals, indicating the major risks of iron deficiency in these individuals, which is consistent with the findings ofL.Zhao et al, who found that the overweight and obese individuals had lower serum iron, Transferrin saturation, and Haemoglobin concentration.[13]

In our study we found that a significant negative correlation was found between the Hemoglobin concentration and Body mass index. Hemoglobin levels in overweight and obese individuals were significantly lower compared to those who weight Normal range. These findings were consistent with the Cross-sectional study conducted by Dina A. Insani et al who stated that there was a correlation that exsisted between Hemoglobin levels and iron status in overweight and obese individuals.[14]

In our study, we found that Haemoglobin levels are decreased

in patients with overweight and Obese individuals, which is in line with our research by Hoi Lun Cheng, who also showed that increased obesity is more often associated with minor disturbances in iron metabolism. Even with increase in BMI of more than 35 kg/m2 only minor changes in the iron levels.[15] The study found a contrast to our research, done by Karlee J.Ausk et al., which indicated that overweight and obese persons were not likely to be anaemic compared with normal-weight persons.[16]

In the study done by Lisa M.Tussing-Humphreys et al, they found that young adult females with obesity had increased hepcidin mRNA expression in adipose tissues, which is associated with iron deficiency in those individuals, compared to those who were lean, which is similar to the findings of our study, where increased body mass index is associated with iron deficiency.[17]

Causal Relation of Iron Deficiency in Overweight and Obese Individuals

In a cross-sectional study conducted by Akram Ghadri-al.I am overweight and obese, and I have an iron deficiency due to low iron levels and reduced iron absorption, which is similar to where the causal role of iron deficiency is attributed to decreased iron intake, reduced absorption, and increased demands in adolescent young girls.[18]

In obese adults, there is a reduced iron store and a greater iron requirement due to inflammation-mediated sequestration of iron in the reticuloendothelial system. This is similar to our study, where iron stores are decreased in young adult females, possibly explaining the mechanism of inflammation-mediated obesity in young adults.[19]

Obesity is claimed to be a chronic inflammatory state resulting in the sequestration of iron in the reticuloendothelial system, leading to hypoferremia, which brings about significant health consequences.[20] A growing concern in the medical field is that obesity at a young age leads to devastating health risks in older individuals, called "Sarcopenic obesity". Patients with sarcopenic obesity have a relative increase in intra-abdominal fat that is greater than subcutaneous or total body fat.[21]

Limitation: The limitation of our study is a smaller sample size. Furthermore, the effects of rapid growth, higher blood volume, and the impact of heavy menstruation on iron status, which are profound contributors to iron deficiency, are not elucidated, and other causal relationships cannot be established.

Conclusion

Iron deficiency anaemia, also known as nutritional anaemia, is more prevalent in females worldwide. In developing countries like India, due to a sedentary lifestyle and the noticeable use of vehicles for Transportation, the use of Lifts rather than climbing stairs contributes to many deteriorating human efforts.There is a major preponderance of females being obese compared to males, mainly due to a lack of exercise.Our study showed a significant negative correlation between haemoglobin and body mass index, as well as body fat percentage, in young adult females.This clearly depicts that an increase in body mass index and Body fat may interfere with normal iron regulation and impair haemoglobin levels in young Healthy females.Adoption of a healthy lifestyle and a brisk 30-minute walk every day may be advocated to combat the ill effects of obesity in young females.

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Conflicts of interest

There are no conflicts of interest.

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