

Original Research Article

Unfeasible body mass index and its association with low haemoglobin concentration: a correlation study among undergraduate medical students

Tazeen Khan¹, Zahid A. Khan^{*2}, Sonia Kochhar¹, Baljinder Singh¹,
Gurdev L. Goyal¹, Ruby Sharma¹

¹Department of Physiology, ²Department of Community Medicine, MM Institute of Medical Sciences and Research, Mullana, Ambala, Haryana, India

Received: 02 October 2018

Accepted: 29 October 2018

*Correspondence:

Dr. Zahid A. Khan,

E-mail: drzahidalikhan@gmail.com

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ABSTRACT

Background: Low hemoglobin concentration and unfeasible body mass index adversely affect the health of people, consequently increasing morbidity and mortality among them. Hemoglobin concentration among individuals is associated with their body mass index. The prevalence of iron deficiency anemia is higher among underweight and overweight/obese people compared to those with normal BMI. Thus, the present study aimed to determine the correlation between hemoglobin concentration and BMI of undergraduate medical students.

Methods: A cross-sectional study was carried out among 210 undergraduate medical students. Body mass index was calculated and hemoglobin estimation was done by Sahli's hemoglobinometer. Correlation between hemoglobin concentration and body mass index of subjects was assessed by Pearson's correlation coefficient.

Results: Underweight students had lowest mean hemoglobin concentration and the mean hemoglobin concentrations increased significantly ($p < 0.001$) with increase in the BMI of subjects. A highly significant positive correlation ($r = 0.307$, $p < 0.001$) between BMI and hemoglobin concentration was observed. Further, significant positive correlation was observed among males ($r = 0.268$, $p = 0.013$), students with normal BMI ($r = 0.283$, $p = 0.003$) and overweight students ($r = 0.415$, $p = 0.035$) only.

Conclusions: Hemoglobin concentration and BMI show a positive correlation, however this correlation tends to become negative in obese individuals. As both low hemoglobin concentration and unfeasible body mass index have detrimental effects on the health, diligent screening and management of both is essential for better outcome.

Keywords: Anemia, Body mass index, Correlation, Gender, Hemoglobin, Iron, Overweight, Obesity, Students

INTRODUCTION

Anemia and malnutrition are the major nutritional public health problems imposing a double burden on populations globally. Low hemoglobin concentration as a result of iron deficiency causes fatigue and reduces work capacity, impairs cognition with low academic performance in children and adolescents, and also has

adverse effects on the pregnancy outcomes.¹⁻⁵ Underweight also increases the risk of low birth weight in pregnancy, and is associated with osteoporosis even in young people.^{6,7} Overweight and obesity in childhood and adolescence is now believed to be a major risk factor for early onset of chronic diseases among adults, and also impedes academic performance in children and adolescents.⁸⁻¹⁰

Anemia affects all individuals from infancy to geriatric age group and the most affected are children and women in adolescence, pregnancy or lactation. The global prevalence of anemia estimated in a systematic analysis was found to be around 32.9% in 2010 for all age groups.¹¹ According to World Health Organization, 42.6% children (6-59 months age) and 38.2% pregnant women aged 15- 49 years were anemic in 2011.¹²

Adolescents are at increased risk of iron deficiency and thus are vulnerable to anemia.¹³ Abnormal body mass index among them further predisposes to risk of developing iron deficiency anemia.¹⁴ Underweight leads to iron depletion and increases the risk of iron deficiency anemia.^{15,16} Overweight or obese children and adolescents also have deranged iron status and thus increased risk of anemia.¹⁷⁻¹⁹ The present study was carried out to determine the correlation between hemoglobin concentration and body mass index of medical students.

METHODS

A cross sectional study was carried out in the department of Physiology of MM Institute of Medical Sciences and Research, Mullana, Ambala, Haryana from April 2016 to June 2016 among 210 undergraduate medical students. A minimum sample size of 195 subjects was estimated at 95% confidence level, power of 80% and taking the anticipated correlation coefficient of 0.199 from a study by Gozkaman A et al.²⁰ Finally 210 first year students, comprising of 140 MBBS and 70 BDS students, were selected for the study. Information regarding age, sex, height, and weight was collected. Body weight was measured to nearest 0.1kg and height was recorded to nearest 0.01m for calculation of body mass index. Subjects were categorized into underweight, normal weight, over weight and obese as per the latest guidelines for BMI classification for Asian Indians (Table 1).²¹ Hemoglobin concentration was estimated using Sahli's Haemoglobinometer up to nearest 0.1gm/dl.

Table 1: Categorization of body mass index for Asian Indians.

BMI (Kg/m ²)	Nutritional status
<18.0 kg/m ²	Underweight
18.0-22.9 kg/m ²	Normal
23.0-24.9 kg/m ²	Overweight
≥25 kg/m ²	Obese

The data were collected from the students after obtaining informed written consent from them. Study participants were assured about the confidentiality of the data and no personal identification was revealed.²¹

Statistical analysis was performed using IBM SPSS Statistics for Windows, Version 20.0. (Armonk, New York: IBM Corp). Mean and standard deviation for

hemoglobin levels and BMI were calculated and gender differences in them were analyzed by student's independent t-test. Difference in the mean hemoglobin concentrations of the subjects according to BMI categories was tested by one way ANOVA and inter group comparison was done by Tukey's Post Hoc test. Correlation between hemoglobin concentration and body mass index of the study subjects was assessed by Pearson's correlation coefficient. A p-value of less than 0.05 was considered statistically significant.

RESULTS

Among 210 students selected for the study, 85 were males and 125 were females. The mean age of students was 18.7±1.0 years and was almost similar for both males and females (p=0.203). Mean height of students was 1.67±0.09 meters and was significantly higher (p<0.001) in males (1.74±0.07) compared to females (1.62±0.06). Males also had significantly higher (p<0.001) mean weight compared to females (71.8±11.2kg and 57.3±9.9kg respectively) (Table 2).

Table 2: Gender differences in age, anthropometry and hemoglobin.

	Total (n=210)	Males (n=85)	Females (n=125)	P value
Age (years)	18.7±1.0	18.6±1.0	18.7±1.0	0.203
Height (m)	1.67±0.09	1.74±0.07	1.62±0.06	<0.001*
Weight (in kg)	63.2±12.6	71.8±11.2	57.3±9.9	<0.001*
BMI (kg/m ²)	22.5±3.6	23.7±3.6	21.8±3.5	<0.001*
Hemoglobin (gm/dl)	11.8±1.6	13.0±1.3	11.0±1.1	<0.001*

*Statistically significant (at p<0.01)

The mean BMI of all the students was 22.5±3.6kg/mt². Mean BMI of male students was 23.7±3.6kg/m², around 2kg/m² higher than female students (21.8±3.5kg/m²) and the difference was statistically highly significant (p<0.001). Males had also around 2gm/dl higher (p<0.001) mean hemoglobin concentration compared to females as mean hemoglobin concentration of male and female subjects was 13.0±1.3gm/dl and 11.0±1.1gm/dl respectively (Table 2).

Underweight students had the lowest mean hemoglobin concentration (11.2±0.8gm/dl) which increased with increase in the BMI of students (p<0.001) and obese students had highest mean hemoglobin concentration (12.5±1.6gm/dl).

However, when stratified according to gender, significant difference in the mean hemoglobin concentration in different BMI categories was observed in male subjects only (p=0.038) (Table 3).

A statistically highly significant positive correlation (r=0.307, p<0.001) of BMI with hemoglobin concentration among the study participants was observed.

However, according to gender, significant positive correlation was observed among male subjects only

($r=0.268$, $p=0.013$) (Table 4).

Table 3: Association of mean hemoglobin levels with body mass index.

Body mass Index	Hemoglobin in g/dl (Mean \pm SD)		
	Total (n=210)	Males (n=85)	Females (n=125)
Underweight	11.2 \pm 0.8 (n=21)	11.8 \pm 0.6 (n=6)	10.9 \pm 0.8 (n=15)
Normal	11.6 \pm 1.5 (n=109)	12.8 \pm 1.3 (n=36)	10.9 \pm 1.2 (n=73)
Overweight	12.2 \pm 1.7 (n=26)	13.3 \pm 1.5 (n=12)	11.3 \pm 0.9 (n=14)
Obese	12.5 \pm 1.6 (n=54)	13.4 \pm 1.3 (n=31)	11.0 \pm 1.1 (n=23)
P value	<0.001**	0.038*#	0.500

*Statistically significant (at $p<0.05$); **Statistically significant (at $p<0.01$); #Tukey's Post Hoc test revealed significant difference in the comparison of hemoglobin levels of underweight and Obese students.

Table 4: Correlation of body mass index (kg/m^2) with hemoglobin (g/dl) levels.

	No.	Correlation coefficient (r)	P value
Overall	210	0.307	<0.001**
Gender			
Males	85	0.268	0.013*
Females	125	0.138	0.124
Body mass Index			
Underweight	21	0.032	0.891
Normal	109	0.283	0.003**
Overweight	26	0.415	0.035
Obese	54	-0.093	0.505

*Statistically significant at ($p<0.05$); **Statistically significant (at $p<0.01$)

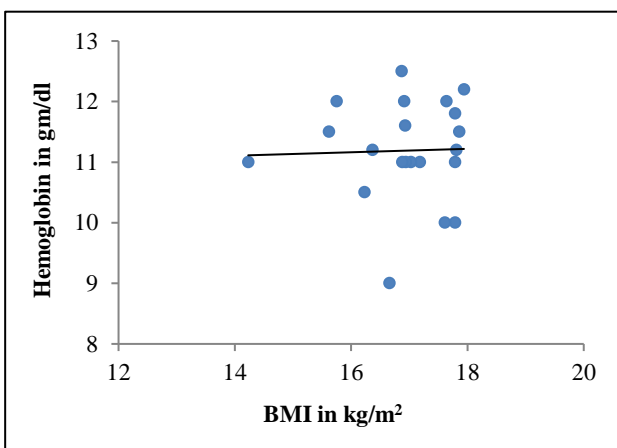


Figure 1: Correlation of hemoglobin concentration (in gm/dl) and body mass index (in kg/m^2) in underweight subjects.

Correlation of BMI with hemoglobin concentration according to BMI categories revealed weak non-significant positive correlation in underweight students ($r=0.032$, $p=0.891$) (Table 4/Figure 1). Only students with normal BMI ($r=0.283$, $p=0.003$) (Table 4/Figure 2)

and overweight students ($r=0.415$, $p=0.035$) (Table 4/Figure 3) depicted a significant positive correlation of BMI with hemoglobin concentration. However, obese students showed a weak non-significant negative correlation ($r=-0.093$, $p=0.505$) (Table 4/Figure 4).

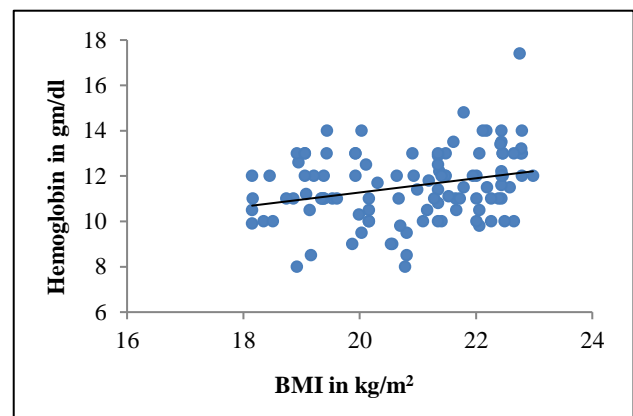


Figure 2: Correlation of hemoglobin concentration (in gm/dl) and body mass index (in kg/m^2) in subjects with normal BMI.

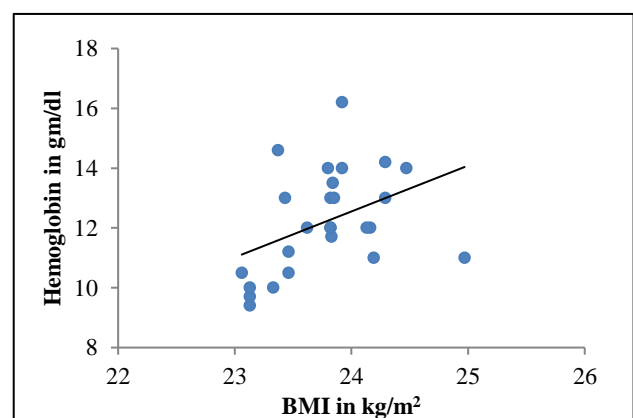


Figure 3: Correlation of hemoglobin concentration (in gm/dl) and body mass index (in kg/m^2) in overweight subjects.

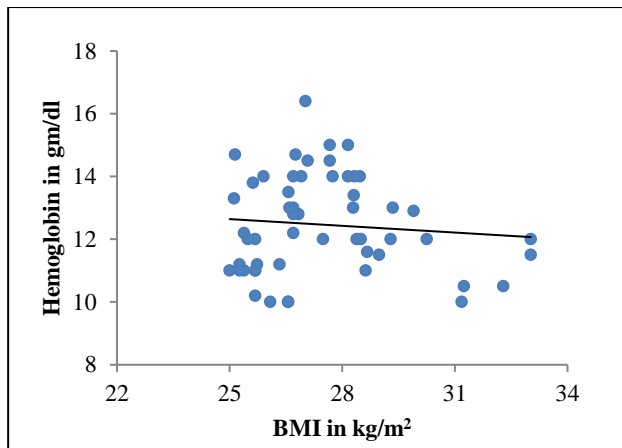


Figure 4: Correlation of hemoglobin concentration (gm/dl) and body mass index (kg/m²) in obese subjects.

DISCUSSION

Anemia and unfeasible body mass index in childhood and adolescence is associated with adverse outcomes.¹⁻¹⁰ There is an increased risk of iron deficiency anemia in adolescents which may be further aggravated by unfeasible body mass index.¹³⁻¹⁹ Consequently, such individuals are predisposed to reduced work capacity, poor academic performance, increased susceptibility to infections, and increase in their long term morbidity and mortality.^{1,2,9,10,22}

In the present study, the mean BMI of all the students was 22.5 ± 3.6 which is much higher than reported in previous studies.²³⁻²⁵ This difference may be attributed to the fact that all the students in the present study were from high socioeconomic class. A study by Yadav et al carried out in same college but different sample of students, reported mean BMI almost similar to our study.²⁶

We observed a significant gender difference in the mean BMI and hemoglobin concentration of the students. Males had an around 2 kg/m^2 higher mean BMI and also 2 gm/dl higher mean hemoglobin level compared to females. Previous studies have reported similar difference in the mean BMI and mean hemoglobin concentration of male and female students.^{23-25,27} Regular iron loss through menstruation and bad dietary habits to maintain low weight and slimness contribute to lower hemoglobin concentration and lower body mass index among females.

The mean hemoglobin concentration increased significantly ($p=0.029$) with increase in the BMI of students. Underweight students had lowest mean hemoglobin concentration compared to normal, overweight and obese students. Previous studies have also reported higher prevalence of anemia in underweight individuals.^{15,16} This may be attributed to the fact that underweight predisposes to iron depletion and increases

the risk of anemia.¹⁶ One study from Indonesia, revealed that the risk of iron deficiency anemia in thin adolescent girls was five-fold higher than non-thin girls.²⁸ Another study from Ethiopia reported that underweight was a significant predictor (adjusted odds ratio= 2.54, $p=0.018$) of anemia in adolescents.²⁹

In our study, overweight and obese students had slightly higher mean hemoglobin concentration though non-significant than students with normal BMI which is similar to findings of a study from Iran.³⁰ We also observed slightly lower mean hemoglobin concentration in female obese students than overweight students. With increase in the BMI towards obesity, there is a fall in the mean hemoglobin concentration as overweight and obesity is an established risk factor for iron deficiency anaemia.¹⁷⁻¹⁹ In our study the mean hemoglobin concentration of obese students was not lower than normal students. This can be attributed to the fact that very few students had BMI of more than 30 kg/m^2 . WHO classifies obesity with BMI of 30 kg/m^2 , whereas, 25 kg/m^2 is the cut off for obesity according to Asian Indian standards for BMI classification, used in this study.²¹

A significant positive correlation ($r=0.307$, $p<0.001$) was observed between body mass index and hemoglobin of students which is similar to findings of previous studies.^{23,30,31} Only male students depicted a significant positive correlation ($r=0.268$, $p=0.013$) and no correlation was observed in females. Similarly, a study from Iraq, also reported significant positive correlation between BMI and hemoglobin among males, however females depicted a significant negative correlation.³² On the contrary, a study from Pakistan revealed significant positive correlation in female and no correlation in male students.³³

Analysis of correlation between BMI and hemoglobin according to BMI categories revealed a significant positive correlation among students with normal BMI ($r=0.283$, $p=0.003$) and in overweight students ($r=0.415$, $p=0.035$) only. Similarly, some studies have also revealed positive correlation among normal BMI students.^{25,27} In our study, obese students depicted a weak negative non significant correlation. However previous studies have reported significant negative correlation between BMI and hemoglobin among overweight/obese students.^{25,27,34} This may be attributed to lower cut off of BMI for obesity in Asian Indians as discussed earlier.

The deranged iron profile indicating iron deficiency is common in overweight and obese individuals.¹⁷ The higher risk of iron deficiency anemia in overweight and obese adolescents may be attributed to lower serum iron availability with increasing adipose tissue in them.¹⁷ Further, obese children have been found to have limited iron absorption from the duodenum compared to normal weight children.³⁵ There occurs macrophage infiltration in adipose tissue of obese individuals leading to

inflammatory response and production of pro inflammatory markers and increased expression of the systemic iron regulatory protein hepcidin.^{36,37} Hepcidin regulates iron homeostasis through blockage of iron export with consequent decrease in serum iron and anemia.³⁷ There is a marked improvement in the iron status and increased iron absorption in obese children who undergo long term weight loss program.^{38,39}

CONCLUSION

Unfeasible body mass index whether underweight or overweight/obesity increases the risk of iron deficiency anemia. Individuals with normal body mass index show positive correlation between hemoglobin concentration and Body mass index. However, there is a tendency of decrease in the hemoglobin concentration with decrease in the BMI among underweight individuals and with increase in the BMI among obese subjects. As both low hemoglobin concentration and unfeasible body mass index have detrimental effects on the health, diligent screening and management of both is essential for better outcome.

ACKNOWLEDGEMENTS

Authors would like to thank the Maharishi Markandeshwar Institute of Medical Sciences and Research Mullana for providing facilities for the study.

Funding: No funding sources

Conflict of interest: None declared

Ethical approval: The study was approved by the Institutional Ethics Committee of Maharishi Markandeshwar Institute of Medical Sciences and Research, Mullana, Ambala, Haryana, India

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Cite this article as: Khan T, Khan ZA, Kochhar S, Singh B, Goyal GL, Sharma R. Unfeasible body mass index and its association with low haemoglobin concentration: a correlation study among undergraduate medical students. *Int J Res Med Sci* 2018;6:4002-7.