

Original article

Prevalence of Anaemia and Its Association with Breakfast Habits and Body Mass Index Among Female Medical Technology Students in Misrata, Libya: A Cross-Sectional Study

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Abstract

Anaemia is common among young women, and university students face particular risk from menstrual blood loss, irregular eating habits, and academic stress. This study assessed haemoglobin (Hb) and packed cell volume (PCV) among female medical technology students in Misrata, Libya, and their association with breakfast habits and body mass index (BMI). A cross-sectional study was conducted on 99 female students. Height, weight, waist and hip circumference were measured to calculate BMI and waist-to-hip ratio. Breakfast habits were recorded using a short questionnaire, and Hb and PCV were measured from venous blood samples and classified using WHO cutoffs. Data were analysed using Pearson correlation, independent t-tests, one-way ANOVA, and chi-square tests, with significance at $p < 0.05$. Mean age was 21.43 ± 1.16 years, mean BMI was 24.63 ± 4.36 kg/m², and mean Hb was 11.84 ± 1.84 g/dL. Overall, 52.5% of students were anaemic (36.4% mild, 16.1% moderate; no severe cases). Hb showed a weak but significant positive correlation with BMI ($r = 0.257$, $p = 0.010$) and waist circumference ($r = 0.227$, $p = 0.024$). Mean Hb did not differ between regular eaters and skippers ($p = 0.482$), though skippers showed more moderate anaemia (22.0%) than regular eaters (12.1%), without reaching significance ($\chi^2 = 4.774$, $p = 0.092$). Anaemia is common among these students, mostly mild-to-moderate. Higher BMI was weakly associated with higher Hb, while skipping breakfast was linked to more moderate anaemia. Routine haemoglobin screening and health education are recommended for this population.

Keywords. Anaemia, Haemoglobin, Breakfast Skipping, Body Mass Index, Libya

Introduction

One of the most prevalent public health issues in the world is anaemia, particularly in women who are of reproductive age [1]. Haemoglobin (Hb) levels below 12.0 g/dL are considered anaemia in non-pregnant adult women by the World Health Organisation (WHO) [1]. According to estimates, anaemia affects over 25% of people worldwide, with young women suffering most of the condition [2]. One group that is especially at risk is female university students. Their requirement for iron and other minerals is increased by the physical and academic demands of college life, as well as the monthly blood loss caused by menstruation [3]. Students who have low haemoglobin levels may feel tired, have trouble focusing, and have less energy and well-being every day [3]. In this case, eating habits are significant. Breakfast is typically the first meal that students miss due to a busy schedule and academic pressure [4].

Iron, folate, and other nutrients required for the production of healthy red blood cells can be found in breakfast. Skipping breakfast was shown to be widespread among Saudi Arabian female nursing students and was associated with haemoglobin status [4]; however, the exact nature of this relationship may vary depending on the community. Body weight is another factor that may affect iron levels, though its effect is not always straightforward. Low-grade inflammation linked to obesity can increase hepcidin levels and decrease the absorption of iron from the diet, and some studies have revealed that students who are overweight or obese have a higher prevalence of anaemia than their counterparts who are of normal weight [5,6]. Other research on female students, however, has discovered the opposite trend, with haemoglobin levels typically increasing in tandem with BMI [4]. Because of this, it is crucial to investigate rather than make assumptions about the relationship between body mass index (BMI) and haemoglobin.

In Libya, research on anaemia among university students is still limited. A recent report from Tarhuna documented a high prevalence of anaemia among university students, confirming that low haemoglobin status is an ongoing health concern nationally [7]. However, no similar data are available for female medical technology students in Misrata, a group whose future clinical work makes their own health status especially important. Therefore, this study aimed to measure haemoglobin and packed cell volume (PCV) levels among female medical technology students in Misrata, Libya, and to examine how these levels relate to their breakfast habits and body mass index. The findings revealed a substantial burden of mild-to-moderate anaemia in this population, with haemoglobin levels showing a modest but significant association with body mass index and breakfast habits.

Methods

Study Design, Setting, and Population

This was a cross-sectional study carried out at the College of Medical Technology, Misrata, Libya, between December 2024 and January 2025. A total of 99 female undergraduate students completed all required measurements and were included in the final analysis ($N = 99$). Participation was voluntary, and informed consent was obtained from each student before data collection. Students with a known chronic blood disorder, an active major infection, or a current pregnancy were

excluded from the study. *Ethical approval for this study was obtained from the Libyan National Committee for Biosafety and Bioethics (Approval No. NBC: 013.H.26.10).*

Data Collection

All anthropometric measurements were taken by trained staff using standard methods. Height was measured without shoes using a stadiometer, to the nearest 0.1 cm, and weight was measured in light clothing using a calibrated digital scale, to the nearest 0.1 kg. Body Mass Index (BMI) was calculated as weight (kg) divided by height squared (m^2), and students were classified according to WHO BMI categories: underweight ($<18.5 \text{ kg/m}^2$), normal weight ($18.5\text{--}24.9 \text{ kg/m}^2$), overweight ($25.0\text{--}29.9 \text{ kg/m}^2$), and obesity ($\geq 30.0 \text{ kg/m}^2$) [8]. Waist circumference (WC) and hip circumference (HC) were measured using a flexible, non-stretch tape, and waist-to-hip ratio (WHR) was calculated as WC divided by HC. Breakfast habits were assessed using a structured self-administered questionnaire adapted from a previously utilised instrument among health sciences undergraduates [4]. Students were grouped into two categories: (1) regular breakfast eaters, who ate breakfast 5 or more days per week, and (2) breakfast skippers, who ate breakfast fewer than 5 days per week or rarely/never ate breakfast.

Laboratory Blood Analysis

A venous blood sample (2–3 mL) was collected from each participant into an EDTA tube under aseptic conditions. A complete blood count (CBC) was performed for each sample using an automated haematology analyser, from which haemoglobin (Hb, g/dL) and packed cell volume (PCV, %) values were obtained. Anaemia was classified according to WHO cutoffs for non-pregnant adult women [1]: non-anaemic/non-anaemic (Hb $\geq 12.0 \text{ g/dL}$), mild anaemia (Hb $10.0\text{--}11.9 \text{ g/dL}$), moderate anaemia (Hb $7.0\text{--}9.9 \text{ g/dL}$), and severe anaemia (Hb $< 7.0 \text{ g/dL}$).

Statistical Analysis

Data were analysed using IBM SPSS Statistics. Continuous variables are presented as mean $\pm$ standard deviation (SD), median (interquartile range, IQR), and range, while categorical variables are presented as frequencies and percentages. Before correlation analysis, the normality of continuous variables was assessed using the Shapiro-Wilk test, which indicated deviation from a normal distribution for all variables ($p < 0.05$). Given the relatively large sample size and the robustness of parametric tests under the Central Limit Theorem, Pearson correlation, independent samples t-tests, and one-way ANOVA were retained as the primary analyses; key correlation findings were additionally verified using Spearman's rank correlation, which confirmed consistent results. Linearity was visually confirmed through scatter plots, and outliers were identified using the interquartile range (IQR) method. Pearson correlation (r) was used to test the linear relationship between Hb, PCV, age, BMI, WC, and WHR. Independent samples t-tests were used to compare mean Hb, PCV, BMI, and WC between regular breakfast eaters and breakfast skippers. One-way ANOVA with Tukey's HSD post-hoc test was used to compare mean Hb and PCV across the four WHO BMI categories, and chi-square (χ^2) tests were used to examine the association between anaemia severity and both breakfast habit and BMI category. A p-value below 0.05 was considered statistically significant.

Results

General Characteristics and Anaemia Prevalence

The descriptive statistics of the 99 participants are summarised in Table 1. The mean age was 21.43 ± 1.16 years, mean BMI was $24.63 \pm 4.36 \text{ kg/m}^2$, mean waist circumference was $76.20 \pm 7.91 \text{ cm}$, and mean WHR was 0.75 ± 0.05 . Haemoglobin concentrations ranged from 7.80 to 18.50 g/dL, with a mean of $11.84 \pm 1.84 \text{ g/dL}$, while PCV values averaged $39.97 \pm 6.50\%$.

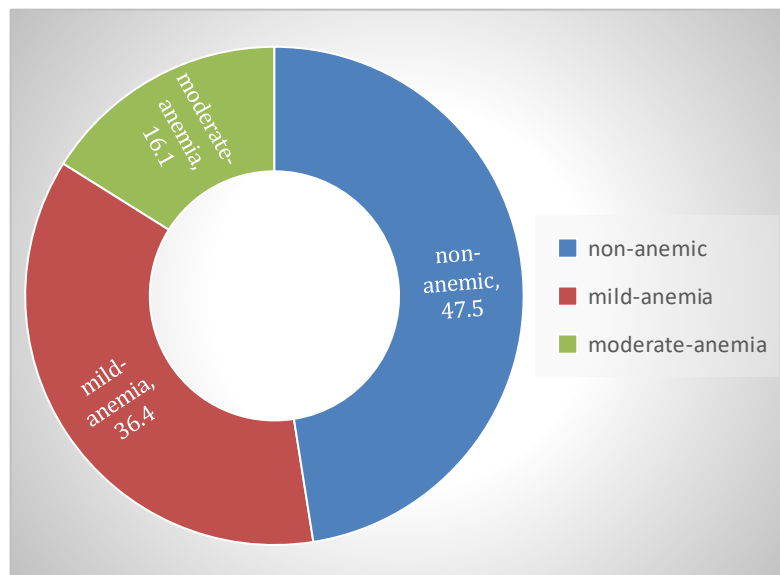
Table 1. Descriptive Statistics of Demographic, Anthropometric, and Haematological Parameters (N = 99)

Variable	Mean $\pm$ SD	Median (IQR)	Min–Max
Age (years)	21.43 ± 1.16	21.00 (1.00)	20.00–25.00
Height (cm)	159.06 ± 5.04	160.00 (7.00)	148.00–172.00
Weight (kg)	62.24 ± 12.28	60.00 (16.00)	39.00–106.00
BMI (kg/m^2)	24.63 ± 4.36	23.63 (6.06)	17.00–36.67
Waist Circumference (cm)	76.20 ± 7.91	75.00 (11.00)	62.00–96.00
Hip Circumference (cm)	101.93 ± 9.88	100.00 (13.00)	84.00–150.00
Waist-to-Hip Ratio	0.75 ± 0.05	0.75 (0.07)	0.53–0.89
Haemoglobin (g/dL)	11.84 ± 1.84	11.80 (2.40)	7.80–18.50
Packed Cell Volume (%)	39.97 ± 6.50	39.50 (8.15)	22.60–70.00

(Table 2) shows the distribution of BMI categories, breakfast habits, and anaemia severity. Based on BMI, 51.5% ($n = 51$) of students had normal weight, 26.3% ($n = 26$) were overweight, 15.2% ($n = 15$) were obese, and 7.1% ($n = 7$) were underweight. Regarding breakfast habits, 58.6% ($n = 58$) ate breakfast regularly, while 41.4% ($n = 41$) skipped breakfast. Overall, anaemia (Hb $< 12.0 \text{ g/dL}$) was found in 52.5% ($n = 52$) of participants: 36.4% ($n = 36$) had mild anaemia, and 16.1% ($n = 16$) had moderate anaemia. No cases of severe anaemia were found (Figure 1).

Table 2. Categorical Distribution of BMI, Breakfast Habit, and Anaemia Status (N = 99)

Characteristic	n	%
BMI Category		
Underweight (<18.5 kg/m ²)	7	7.1%
Normal weight (18.5–24.9 kg/m ²)	51	51.5%
Overweight (25.0–29.9 kg/m ²)	26	26.3%
Obesity (≥30.0 kg/m ²)	15	15.2%
Breakfast Habit		
Eats breakfast regularly	58	58.6%
Skips breakfast	41	41.4%
Anaemia Severity		
Non-anemic (≥12.0 g/dL)	47	47.5%
Mild anaemia (10.0–11.9 g/dL)	36	36.4%
Moderate anaemia (7.0–9.9 g/dL)	16	16.1%
Severe anaemia (<7.0 g/dL)	0	0.0%

**Figure 1. Overall prevalence of anaemia among participants (N = 99).****Correlation Between Haemoglobin and Anthropometric Measurements**

(Table 3) shows the Pearson correlation matrix. Haemoglobin had a weak but statistically significant positive correlation with BMI ($r = 0.257$, $p = 0.010$) and waist circumference ($r = 0.227$, $p = 0.024$). PCV showed a strong positive correlation with haemoglobin ($r = 0.596$, $p < 0.001$), as expected. Age and WHR were not significantly correlated with Hb or PCV (Figure 2).

Table 3. Pearson Correlation Matrix Between Haemoglobin, PCV, and Anthropometric Measurements (N = 99)

Parameter	Hb	PCV	Age	BMI	WC	WHR
Haemoglobin	1.000					
PCV	0.596***	1.000				
Age	0.088	0.038	1.000			
BMI	0.257*	0.067	0.082	1.000		
Waist Circumference	0.227*	0.053	0.088	0.846***	1.000	
Waist-to-Hip Ratio	0.073	-0.021	0.054	0.264**	0.573***	1.000

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$ (2-tailed).

WHR	WC	BMI	Age	PCV	HB	
0.073	*0.227	*0.257	0.088	0.596	1	HB
-0.021	0.053	0.067	0.038	1	0.596	PCV
0.054	0.088	0.082	1	0.038	0.088	Age
*0.264	*0.846	1	0.082	0.067	*0.257	BMI
*0.573	1	*0.846	0.088	0.053	0.227	WC
1	*0.573	*0.264	0.054	-0.021	0.073	WHR

Colour intensity represents the strength of the Pearson correlation coefficient (r); darker shades indicate stronger positive correlations. * p < 0.05 (2-tailed)

Figure 2. Correlation matrix of haemoglobin, PCV, and anthropometric parameters (N = 99).

3.3 Comparison by Breakfast Habit and BMI Category

As shown in (Table 4), independent samples t-tests found no statistically significant differences between regular breakfast eaters and breakfast skippers in mean Hb (11.95 ± 1.83 vs. 11.69 ± 1.87 g/dL, $p = 0.482$), PCV ($40.54 \pm 7.15\%$ vs. $39.17 \pm 5.43\%$, $p = 0.302$), or BMI (24.71 ± 4.38 vs. 24.52 ± 4.38 kg/m², $p = 0.836$).

Table 4. Independent Samples t-Test Comparing Biomarkers by Breakfast Habit

Parameter	Eats Breakfast (n=58)	Skips Breakfast (n=41)	t	Haemoglobin	p-value
Haemoglobin (g/dL)	11.95 ± 1.83	11.69 ± 1.87	0.706	97	0.482
PCV (%)	40.54 ± 7.15	39.17 ± 5.43	1.038	97	0.302
BMI (kg/m ²)	24.71 ± 4.38	24.52 ± 4.38	0.208	97	0.836
Waist Circumference (cm)	76.24 ± 8.21	76.15 ± 7.56	0.058	97	0.954

One-way ANOVA (Table 5) showed a marginally significant difference in mean Hb across BMI categories ($F = 2.557$, $p = 0.059$). Overweight (12.47 ± 2.14 g/dL) and obese (12.38 ± 1.40 g/dL) participants tended to have higher mean Hb than normal-weight (11.40 ± 1.76 g/dL) and underweight (11.61 ± 1.32 g/dL) participants. PCV did not differ significantly across BMI categories ($p = 0.875$).

Table 5. One-Way ANOVA of Haemoglobin and PCV Across WHO BMI Categories

Parameter	Underweight (n=7)	Normal (n=51)	Overweight (n=26)	Obesity (n=15)	F	p-value
Hb (g/dL)	11.61 ± 1.32	11.40 ± 1.76	12.47 ± 2.14	12.38 ± 1.40	2.557	0.059
PCV (%)	38.93 ± 4.09	39.69 ± 6.38	40.67 ± 7.82	40.21 ± 5.37	0.231	0.875

Association Between Anaemia Severity, Breakfast Habit, and BMI

Chi-square analysis (Table 6) showed no statistically significant association between breakfast habits and anaemia severity ($\chi^2 = 4.774$, $p = 0.092$). Although moderate anaemia was more common among students who skipped breakfast (22.0%) than those who ate it regularly (12.1%), as shown in (Figure 3), this difference was not statistically significant. Anaemia severity also did not differ significantly across BMI categories ($\chi^2 = 8.073$, $p = 0.233$).

Table 6. Cross-Tabulation and Chi-Square Test of Anaemia Severity by Breakfast Habit and BMI Category

Variable	Non-anaemic n (%)	Mild n (%)	Moderate n (%)	χ^2	df	p-value
Breakfast Habit				4.774	2	0.092
Eats Breakfast (n=58)	25 (43.1%)	26 (44.8%)	7 (12.1%)			
Skips Breakfast (n=41)	22 (53.7%)	10 (24.4%)	9 (22.0%)			
BMI Category				8.073	6	0.233
Underweight (n=7)	3 (42.9%)	4 (57.1%)	0 (0.0%)			
Normal Weight (n=51)	21 (41.2%)	17 (33.3%)	13 (25.5%)			
Overweight (n=26)	14 (53.8%)	10 (38.5%)	2 (7.7%)			
Obesity (n=15)	9 (60.0%)	5 (33.3%)	1 (6.7%)			

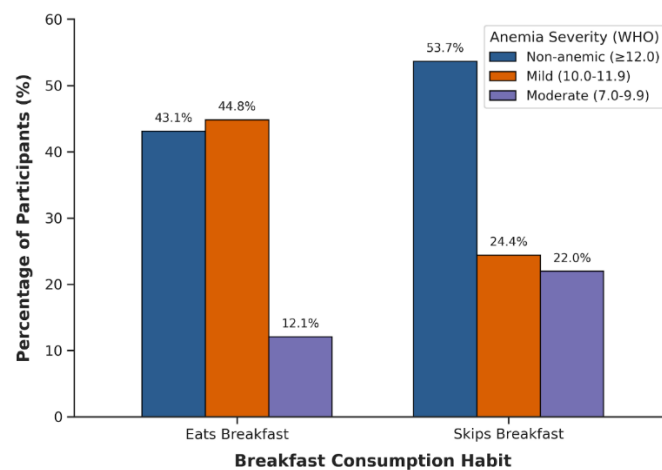


Figure 3. Prevalence of anaemia severity categories by breakfast habit (N = 99)

Discussion

According to this study, 52.5% of Misrata's female medical technology students had anaemia ($Hb < 12.0$ g/dL), with only mild and moderate instances and no severe cases. This percentage is similar to reports of female university students in other developing-country contexts, such as 48.1% of undergraduate students in Somalia [9] and 51.6% of nursing students in Saudi Arabia [4]. Although low haemoglobin concentration is prevalent in this population, the lack of severe instances indicates that it generally presents as mild-to-moderate physiological impairments appropriate for basic healthcare evaluation and dietary therapy. Haemoglobin concentration was found to have a weak positive correlation with both waist circumference ($r = 0.227$, $p = 0.024$) and BMI ($r = 0.257$, $p = 0.010$). Despite reaching statistical significance, the correlation strength is still weak, suggesting that BMI only partially explains haemoglobin variance. Previous research on university students has shown similar modest correlations between BMI and haemoglobin levels [4], and a large, nationally representative study from Myanmar found a similar positive correlation between BMI and haemoglobin in women [10]. This may seem to conflict with the widely held belief that obesity reduces iron levels by increasing the hormone hepcidin, which prevents the absorption of iron [5,11].

The inflammatory impact of increased body fat on iron absorption may be counteracted, though, if students with a higher BMI simply eat more food overall, including more meals containing iron. This explanation is still simply a hypothesis rather than a confirmed mechanism because this study only measured Hb and PCV and did not directly evaluate iron, ferritin, or food intake. Regarding breakfast habits, there was no significant difference in mean Hb or PCV between students who ate breakfast regularly and those who skipped it. Breakfast skippers had a descriptively greater percentage of moderate anaemia (22.0%) than frequent breakfast eaters (12.1%), but this difference was not statistically significant ($p = 0.092$), indicating a non-significant trend. This pattern is consistent with research from nursing students in Saudi Arabia, where breakfast skipping was widespread among those with poorer haemoglobin status [4], and Pakistan, where a high prevalence of breakfast skipping (60.9%) was associated with a greater proportion of moderate anaemia [12]. A possible explanation is that skipping breakfast may not lower haemoglobin immediately, but repeated skipping over time may slowly reduce the body's iron stores, eventually leading to lower haemoglobin levels in some students. A larger sample may be needed to confirm this potential trend with stronger statistical evidence. There are a few limitations to this study. Because of its cross-sectional design, we are unable to verify a causal relationship between breakfast habits, BMI, and anaemia. Furthermore, the precise cause of anaemia could not be identified because iron status indicators such as serum ferritin were not assessed. Lastly, the sample was selected from a single institution, which limited the generalizability of the results, and breakfast habits were self-reported, which could introduce recall bias.

Conclusion

This study found a high prevalence of anaemia (52.5%) among female medical technology students in Misrata, Libya, occurring mostly in mild-to-moderate forms. Higher BMI and waist circumference were weakly but significantly associated with higher haemoglobin levels. While skipping breakfast did not significantly lower average haemoglobin, it was associated with a higher rate of moderate anaemia.

Ethical Approval

This study was conducted in accordance with standard ethical principles for minimal-risk research. Written informed consent was obtained from all participants prior to data collection, and confidentiality of personal data was maintained throughout the study. Retrospective ethical approval for this study was obtained from the Libyan National Committee for Biosafety and Bioethics (LNCBB), Approval No. NBC: 013.H.26.10.

Authors' Contributions

Sumaia Omar Abu Zayan and Omar Khalifa Alatresh jointly conceived and designed the study. Both authors contributed to

data collection, performed the statistical analysis, interpreted the results, and drafted and critically reviewed the manuscript. Both authors read and approved the final version of the manuscript.

Conflicts of Interest

The authors declare no conflicts of interest.

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Data Availability

The datasets generated and analysed during the current study are available from the corresponding author upon reasonable request.

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