Original Article

Qualitative and Biochemical Assessment of the Impact of Dietary Habits and Body Mass Index on Hemoglobin Levels in Female University Students

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ABSTRACT

OBJECTIVE: To assess the body mass index, dietary habits, signs, symptoms, and biochemical parameters of anemia in female students.

METHODOLOGY: The present cross-sectional analytical study was conducted between August and December 2023 at Public Sector University in Karachi, Pakistan. The eligibility criteria were unmarried females aged 18-25 years. Participants with diagnosed hemoglobinopathy or bleeding disorders, nutritional deficiency anemia, previous anemia treatment, and chronic disease were excluded. The sample size was 393 with convenience sampling. Demographic variables, years of education, ethnicity, rural or urban setting, cultural background, monthly family income, Body Mass Index and folic acid/ multivitamins supplements were assessed through a validated questionnaire. 5ml of venous blood was collected, and complete blood count and serum iron was measured. WHO criteria were used for anemia diagnosis. Data was analyzed using SPSS 28. T-test and Chi-Square test were used for categorical data.

RESULTS: The study found an equal proportion of normal and overweight participants (41%) followed by underweight (18%). Most females skip breakfast, consume vegetables less than three times a week, and consume fruits more than three times. 91% eat fish less than three days a week and consume fast food and soft drinks less frequently. The prevalence of anemia was 46%, followed by mild (13.6%) and moderate (31.8%) anemia. The common symptoms experienced included unusual fatigue, weakness, confusion, a loss of focus, and feelings of sadness or depression.

CONCLUSION: The B.M.I. and inadequate dietary habits impact the general health and serum iron levels in female students, which can be improved by dietary intervention.

KEYWORDS: Anemia, Dietary habits, General Health, Iron deficiency, Female Students

INTRODUCTION

Anemia is characterized by low hemoglobin levels by age and gender[1]. Anemia affected 1.92 billion people worldwide in 2021, with a rise of 420 million cases over the past three decades. However, a global shift towards less severe anemia was observed only in adult males, but women and children showed slower rates of decline[2].

Anemia is primarily caused by iron deficiency, which can be avoided with a healthy diet[3]. The occurrence of iron deficiency differs by age, gender, and developmental phase. While iron deficiency is widespread, specific demographics, including young women, are at increased risk for this condition.

National nutritional surveys have found that between 50% and 55% of anemia cases occur in women living in agricultural and urban regions of Pakistan[4]. Young women are at an elevated risk for the emergence of nutritional disorders, such as iron deficiency, as a result of a confluence of factors, including inadequate dietary practices, menstrual blood loss, heightened physiological demands, stress, and restricted access to nutrient-rich foods. In addition, the risk of anemia is also patterned by the level of education, societal practices, and socio-economic status, especially in this population group[5]. College or university is a crucial time when students, for various reasons, experience unhealthy changes in their eating habits and lifestyle[6].

The phase of emerging adulthood, which spans from age 18 to 25, is a critical period for young individuals to develop a sense of independence, formulate healthy habits that last a lifetime, and adopt unhealthy behaviors that increase the risk of poor overall health[7,8]. Higher education is associated with better knowledge of dietary and lifestyle choices, but there is no evidence that this knowledge is translated into actions that promote long-term health[9]. Poor general health and nutritional habits in female students can have severe implications in terms of future pregnancy. Proper nutrition in young women before pregnancy is crucial for several reasons, including its impact on maternal and child health. Inadequate nutrition can lead to poor maternal and neonatal outcomes, such as low birth weight and preterm birth.

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Moreover, a poor diet can result in low iron levels, leading to fatigue and weakness, poor cognitive performance, memory deficits, and decreased concentration. Inadequate nutrition can also weaken the immune system, making women more susceptible to infections and increasing the risk of adverse outcomes during pregnancy, such as maternal mortality, low birth weight, and preterm birth[10,11].

Anemia is a multifaceted condition that various dietary, physiological, and socio-economic factors can influence. There is insufficient data on food consumption patterns and the nutritional status of women aged 21 to 24 in Pakistan. Understanding how diet, symptoms, signs of anemia, and iron status interact is essential to provide valuable insights into the causes of anemia in this population. Due to the lack of comprehensive information about their dietary habits and nutritional status, it is challenging to address the prevalence and causes of anemia adequately.

Therefore, research is needed to bridge this knowledge gap and clarify the factors contributing to anemia in this specific demographic group. Furthermore, there is no correlation between the available data on diet consumption patterns and nutritional status with the anemia status of female students in Pakistan. Identifying modifiable risk factors and areas for intervention, such as dietary supplementation or education on nutrition and iron-rich foods, can help public health efforts be more effectively directed toward reducing the burden of anemia in this population. The objectives of this study are to assess the food intake patterns, anemia signs and symptoms, and iron status of female students to determine the influence of these factors on the anemia status of female students.

METHODOLOGY

This cross-sectional analytical study was conducted from August to December 2023 at the University of Karachi, Karachi, Pakistan. The sample size was determined using Rao-Soft 2004 calculator, based on a population size of 500 and a response distribution of 50%, yielding a final sample size of 393.

The participants included were unmarried females between 18 and 25 years of age. Patients with a history of thalassemia, hemoglobin or bleeding disorders, nutritional deficiency anemia, previous anemia treatment, chronic disease, and refusal of informed consent were excluded. Written informed consent was obtained before recruitment. The study received approval from the institutional Ethics Review Committee.

Anthropometric measurements were collected to evaluate the general health of the study participants. Trained personnel used a portable dial scale (Professional Dial Scale, Model 150, Health-O-Meter Inc., Bridgeview, Illinois) to measure body weights to the nearest pound, then converted to kilograms. Height was measured without shoes to the nearest 0.1 cm. Each participant's body mass index (B.M.I.) was calculated as kg/height [m^2] [12] using a set square against a wall and a tape measure. A General Health Questionnaire was employed to collect qualitative data on eating patterns, general health, menstruation history, and symptoms of anemia. A validated food frequency questionnaire (F.F.Q.) was modified for this study by adding commonly consumed foods (fast foods, soft drinks) and meal-skipping habits among university students. The study questionnaire was pre-tested with 200 female students to assess clarity and content.

Adjustments were made based on feedback. Reliability was confirmed with a Cronbach's alpha of 0.71 for the general health assessment. Participants rated the intake of specified food items on a Likert-type scale, with options ranging from 1 (Never) to 5 (Daily). These responses totalled a score out of 50. Similarly, participants rated the severity of anemia symptoms on a Likert scale from 0 (All of the time) to 5 (None of the time). These responses were summed to calculate a score out of 45. The presence of specific anemia signs was rated on a dichotomous scale of 5= Yes and 0= No; the total score was out of 20. Dietary supplement use was excluded due to incomplete data regarding iron content. Data from the study questionnaire were independently analyzed by trained staff, and an aggregate score was obtained. Those scoring 59 or below were categorized as having impaired general health. Five milliliters of blood samples were drawn from each participant to analyze complete blood count and serum iron levels. After observing all aseptic measures, a phlebotomist collected the blood sample in EDTA tubes and analyzed it within seven hours with a Sysmex (XN-3000) automated analyzer. The serum iron was measured by reducing ferric iron into ferrous form. It was separated from transferrin in an acidic solution to combine with a chromogen to produce a blue chromophore, which was then read at 595 nm. After mixing and incubating at 15 to 25 ^{0}C or 37 ^{0}C for at least 15 minutes, the final absorbance was read at 595 nm against the reagent blank. Initial absorbance was subtracted from final absorbance to give ΔA for the sample and standard[13.]

All data analyses were performed using the Statistical Package for the Social Sciences (SPSS) (Version 28 for Windows, SPSS Inc., Chicago, Illinois). For every quantitative variable, group means were compared using the Independent Samples t-test (two-tailed) method. A two-sided Pearson's Chi-Square test was utilized to compare groups with categorical data.

RESULTS

During the recruitment phase, 393 female university students were invited to participate in the study. Three hundred fifty students participated in at least some of the data collection process, resulting in an 89% response rate. Due to withdrawals and absences during surveying and testing, 303

participants completed all phases of the data collection process (including the study questionnaire, anthropometric measurements, and blood draws), resulting in a 77% response rate). Equal proportions of normal and overweight females (40.9%) were observed, followed by the underweight (18.2%). Most of the females had less than 16 years of education (80.85%), were Urdu speaking (53.7%), and belonged to low–middle socio-economic status (65.7%). The mean Hb was 12.1±1.86 g/dL, and serum iron was 52.45±28.42 µ/dL. Based on a general health questionnaire (GHI), the majority of female students reported experiencing symptoms and signs of anemia at various intervals, yet not consistently. Unusual fatigue or weakness, confusion or loss of focus, and sadness or depression were experienced all and most of the time by a majority of participants, and unusually pale skin was the most common reported symptom (**Table I**).

TABLE I: FREQUENCY OF ANEMIA SYMPTOMS AND SIGNS IN FEMALE STUDENTS (n=303)

Variables	Response	% (n)
Anemia symptoms		
Unusual fatigue	All of the time	21 (64)
	Most of the time	16.5 (50)
Shortness of breath at rest	All of the time	11.8 (36)
	Most of the time	3 (9)
Poor concentration	All of the time	28.3 (86)
	Most of the time	12.2 (37)
Dizziness	All of the time	20.4 (62)
	Most of the time	4 (12)
Rapid heartbeat	All of the time	23.7 (72)
	Most of the time	11.2 (34)
Sad or depressed	All of the time	26 (79)
	Most of the time	12 (37)
Poor sleep	All of the time	19.8 (60)
	Most of the time	12.8 (39)

It was observed that most of the female students skipped daily breakfast followed by lunch and dinner. Moreover, 48% of females consumed vegetables less than three times per week. However, 59% consumed fruits more than three times per week. Most female students (91%) eat fish only for less than 3 days a week, and 74% consume fast food and soft drinks less than three times a month (**Table II**).

According to WHO criteria, the overall prevalence of anemia was 46% (139 out of 303), and all anemic female students demonstrated low serum iron indicating iron deficiency anemia. Comparison of B.M.I. groups, cultural background, and biochemical parameters of iron status showed a significant difference ($p<0.05$) between the non-anemic and anemic groups with low serum iron. Only one anemic female participant was categorized as anemic by a GHI, whereas participants categorized as non-anemic by GHI demonstrated significant differences between their Hb levels by anemia status (**Table III**).

TABLE II: DIETARY HABITS ASSESSMENT OF FEMALE STUDENTS (n=303)

Variables	Response	% (n)
Regular meal Intake		
Breakfast	Always	36 (110)
	Usually	22.4 (68)
	None/Occasional	10.5 (32)
Lunch	Always	40 (115)
	Usually	25 (76)
	None/Occasional	4.6 (14)
Dinner	Always	57.7 (175)
	Usually	26.7 (81)
	None/Occasional	2.6 (8)
Healthy Dietary Practice		
Vegetable intake	Daily	14 (43)
	Once in 3days	38 (116)
	None/Occasional	4 (12)
Fish intake	Daily	4 (12)
	Once in 3days	5 (15)
	None/Occasional	17.8 (54)
Fruits intake	Daily	30.6 (93)
	Once in 3days	27.7 (84)
	None/Occasional	3.6 (11)
Unhealthy Dietary Practice		
Carbonated drinks intake	Daily	12.5 (38)
	Once in 3days	21.4 (65)
	None/Occasional	9 (28)
Junk food intake	Daily	13.5 (41)
	Once in 3days	12.8 (39)
	None/Occasional	5 (16)

TABLE III: COMPARISON OF ANTHROPOMETRIC, DEMOGRAPHIC, AND HEMATOLOGICAL PARAMETERS AND IRON LEVEL BY ANEMIA STATUS OF FEMALE STUDENTS (n=303)

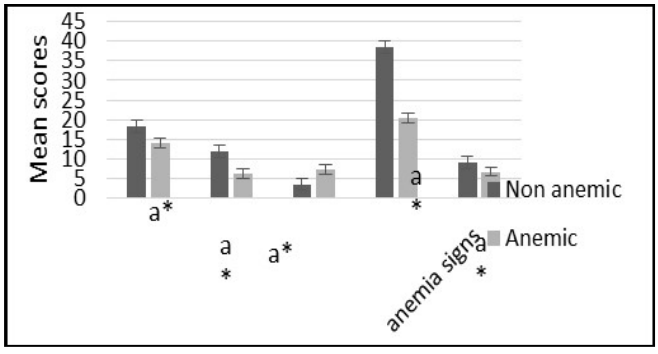
B.M.I. groups	Anemia Status		P value
	Non Anemic (Hb>12 g/dL)	Anemic (Hb<12 g/dL)	
Underweight (n=64)	14.4 ± 0.0	9.88 ± 1.58	0.0001***
Normal (n=143)	13.56 ± 1.13	10.60 ± 0.70	0.0001***
Overweight (n=143)	13.51 ± 0.95	11.4 ± 0.0	0.0001***

Cultural background			
Urdu Speaking	13.51±0.95	10.71±0.70	0.0001***
Others	13.77±1.01	9.88±1.58	0.01**
Monthly Income			
≤.100,000 PKR	14.4 ± 0.0	9.88±1.58	0.0001***
>100,000 PKR	13.52 ± 0.94	10.46 ± 1.02	0.0001***
General Health Status			
≤59	14.5 ± 0.0	10.63 ± 0.0	
>59	13.51± 0.93	10.45±1.08	0.0001***
Hematological parameters			
Hb (g/dL)	13.6 ± 0.93	10.46 ± 1.02	0.0001***
M.C.V (fl)	87.50 ± 7.69	81.91± 2.90	0.04*
M.C. H (pg)	29.96 ± 3.30	26.82 ± 1.03	0.009**
Iron (µ/dL)	73 ±22.89	27.8 ± 2.52	0.0001***
≥ 37 µ/dL [a]	13.6 ± 0.93	--	
< 37 µ/dL [b]	-	10.46 ± 1.02	

*[a]Iron sufficient, [b]Iron deficient, *significant, **highly significant, ***extremely significant*

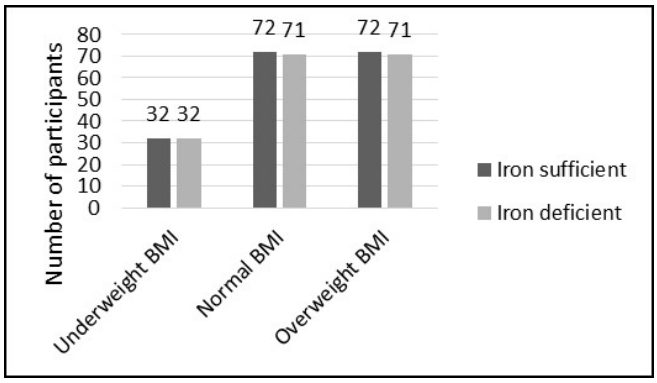
The mean scores were significantly different for regular meal intake, healthy and unhealthy dietary practices, and anemia signs and symptoms scores were significantly different between non-anemic and anemic groups (**Figure I**). Lower aggregate scores of regular meal intake and healthy dietary practice in the anemic group supported the risk of anemia and higher aggregate scores of unhealthy dietary practice compared to the non-anemic group. More female students with normal and overweight B.M.I. showed low serum iron levels (**Figure II**). Furthermore, this study also found a significant association between serum iron and anemia in participants. However, there was no significant association between B.M.I. groups, cultural background, and socio-economic status of anemic and non-anemic females.

FIGURE I: COMPARISON OF DIETARY HABITS AND ANEMIA ASSESSMENT SCORES BY ANEMIA STATUS IN FEMALE STUDENTS (n=303)



A * = p<0.05 when comparing the non-anemic with the anemic group.

FIGURE II: SERUM IRON LEVELS OF FEMALE STUDENTS CONCERNING BODY MASS INDEX (n=303)



DISCUSSION

The present study found an equal proportion of normal and overweight students followed by the underweight, which was in agreement with a high prevalence of overweight and obesity, ranging from 13% to 52.6% among female students of Karachi and Lahore[14,15]. The prevalence of anemia, obesity, and overweight among female university students is high in the present study. Low serum iron levels in the study sample appear to be linked to body fat percentages and poor dietary habits, which were also observed in female university students in Dubai, United Arab Emirates[12,16]. Dietary behaviors like inadequate fiber intake, frequent consumption of red meat, a tendency to skip breakfast, a high number of meals, and snacking habits have been identified as contributing factors. The findings of the study about the unhealthy eating habits of female students are consistent with and supported by earlier research conducted both in Pakistan and globally[17,18]. Also, the majority of students consumed fewer vegetable portions every week than those that were previously published[19].

The anemia symptoms and signs were more prevalent in anemic female students. Fatigue and lack of concentration were the most recurrent symptoms in the study sample, consistent with the previous research[20]. Fatigue and lack of concentration can significantly undermine academic performance, leading to diminished productivity and impaired cognitive function. Fatigue arising from anemia may prevent individuals from engaging in regular physical activity or maintaining a healthy lifestyle, perpetuating a cycle of fatigue and reducing physical health as the body's iron or hemoglobin levels are closely connected factors of physical strength and exercise capability. The reduced dietary iron content leads to decreased levels of essential neurotransmitters like dopamine, serotonin, and epinephrine, which are crucial for cognitive ability and may cause a lack of concentration in females. Chronic fatigue and lack of concentration due to anemia can significantly impede

the quality of life of female university students, affecting their ability to enjoy leisure activities and maintain an equitable lifestyle[21].

The present study findings suggest that the prevalence of iron deficiency anemia in this convenience sample of young females agreed with previous estimates for women of reproductive age in the same region[22,23]. Data published from Pakistan shows that iron deficiency anemia (I.D.A.) is relatively high among women of reproductive age despite younger women being more knowledgeable. Still, this knowledge is not translated into action[24]. A community-based study in Karachi identified low dietary iron intake, often from non-heme iron sources, frequent tea consumption, infrequent red meat consumption, history of malaria, and irregular deworming as risk factors of I.D.A. among female university students[25]. The present study observed both overweight and underweight individuals in equal proportions, and each extreme of the weight spectrum may have consequences for impaired iron status. Overweight individuals might consume diets low in iron-rich foods, while underweight individuals might be malnourished and lack essential nutrients, including iron[12]. Some individuals may have genetic predispositions that affect their ability to absorb or utilize iron efficiently, increasing their susceptibility to iron deficiency anemia[3].

CONCLUSION

This study found a high prevalence of both overweight and anemia among female university students, with poor dietary habits contributing to iron deficiency. The nutritional education and interventions targeted at young females may reduce the risk of anemia and related health issues. Furthermore, the relationship between body mass index and iron status underscores the need for personalized nutrition and health strategies. Addressing these nutritional gaps can improve young women's cognitive function, academic performance, and overall quality of life.

FUTURE RECOMMENDATIONS

Targeted nutritional education programs for female university students are essential for promoting healthy dietary habits and discouraging unhealthy eating patterns. Regular university screening programs should detect iron deficiency and other nutritional issues early for early interventions for at-risk individuals. Interventions addressing weight spectrums, promoting iron-rich foods for overweight individuals, and personalized nutrient-dense plans for underweight individuals can enhance overall health and academic performance.

LIMITATIONS

A few limitations to this study should be mentioned. Firstly, a food frequency questionnaire (F.F.Q.) was used to measure dietary intake; however, despite their widespread use, F.F.Q.s may overestimate or underestimate food consumption due to recall bias and self-reporting errors. This limitation could influence the reliability of study findings regarding regular and healthy food intake among the participants. Secondly, due to its convenience sample design, the study results may not fully represent the broader population, especially those from lower socio-economic backgrounds. Additionally, the study did not use serum ferritin measurements, which can enhance the accuracy of iron deficiency anemia diagnosis, which may limit the process's precision. Lastly, the data for dietary supplements was excluded due to inconsistency in dietary supplement use and type, which may affect the assessment of the nutritional status of study participants.

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Data Sharing Statement: The corresponding author can provide the data proving the findings of this study on request. Privacy or ethical restrictions bound us from sharing the data publicly.

AUTHOR CONTRIBUTION

Tariq H: Data collection, data analysis and manuscript writing

Sohail A: Data analysis, data interpretation and manuscript drafting

Qureshi SA: Study design and concept, questionnaire design and review and editing

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