Original Article

Iron Deficiency Amongst University Graduates; Prevalence, Diagnosis, and Iron Consumption

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Abstract

Anemia is a worldwide epidemic, and iron deficiency is a leading cause of anemia. We used anthropometric measurements and a multi-sectioned questionnaire to get as much information about diet as possible. The blood was taken to determine their iron stores via a test measuring their hemoglobin (Hb). Iron deficiency was examined alongside gender, body mass index, family history, the variety and quantity of the foods eaten, the frequency of eating each of the five main food groups, and the prevalence of anemia. The correlation between dietary factors like grains, protein, dairy, vegetables, and fruits, and iron levels was also performed. The percentage of underweight men ranged from 2% to 14%, while 6% to 4% and stages II and III obesity were each found among men. Ten percent of men with normal blood iron levels were found to have mild iron deficiency. When it comes to women, 32% were underweight while only 6% were in stage I obesity. Although supplement use can improve health by lowering the risk of problems associated with iron deficiency, it can also cause gastrointestinal distress in some people. It can raise the supplement's already high risk of kidney or gallstone formation. Therefore, a study examining the correlation between iron deficiency anemia and specific nutrients could raise consciousness about the importance of eating healthfully and maintaining proper nutrient levels in the body. Scientific research and medical diagnosis will benefit from this as well.

Keywords: Anemia, Hemoglobin, Body iron, Mass index, Diet, Micronutrient

Introduction

Micronutrients play an important role in our body as their deficiencies can cause serious health issues. Their levels in the body are a true predictor of a person's nutritional status. Micronutrients are compounds that are only required in a minimal amount in the body, which helps in the body's growth, development, and maintenance [1]. Micronutrient deficiencies are so important to public health outcomes, particularly in the developing world, that a series of global goals have been established [2]. The most frequently used micronutrients are vitamins and minerals. Out of all minerals, Iron is the most significant for our body. Iron is one of the most important minerals and an integral component of Hemoglobin. It plays a significant role in our bodies. The highlighted roles include neurological development, intelligence level (IQ), physical growth, and cellular functioning. Iron deficiency is one of the nutritional disorders that is prevailing globally. It can occur in any age group. Extreme low levels of Iron in the body can cause iron deficiency anemia (IDA). According to World Health Organization, it is a condition in which the number of red blood cells or their oxygen-carrying capacity is insufficient to meet physiological needs, which vary through age, gender, altitude, smoking, and pregnancy status. Furthermore, the prevalence of iron deficiency anemia globally is between 1.5 and 1.7 billion people, 24.8% of the world population. In preschool children, the prevalence is 47.4%, which is the highest and the lowest in adult men, about 12.7%. Globally in 2019, anemia prevalence was 22.8% [3]. Some major reasons behind iron deficiency include massive blood loss and hemorrhages. Other reasons include pregnancy when female micronutrients demand increases. Malaria is also one of the reasons for iron deficiency causing intravascular hemolysis with subsequent loss of hemoglobin iron in the urine. One of the major reasons for iron deficiency is poor dietary intake; malabsorption of Iron causes malnourishment [4]. Worldwide, iron deficiency is among those continuing to spread in all age groups, mainly targeting developing countries, and present in both males and females at different ratios. Mainly it is categorized into two forms: absolute or functional. When total body iron reserves are at a low-level

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such type is known as an absolute iron deficiency; The type in which total body reserves are normal but the supply to bone marrow is inadequate such type is known as functional iron deficiency. Absolute and functional deficiencies can coexist. Functional iron deficiency can occur in many acute and chronic inflammatory states [5]. These disorders do not appear suddenly; by closely analyzing them, we know they all have an old background. These deficiencies occur in childhood, but at that time, they are in a milder stage, due to which identification is difficult. As the child grows older, the nutritional requirements also increase in the body, but deficiencies may arise due to an imbalanced diet. If measures should not be taken at the proper time, then they become moderately to severely malnourished. In Pakistan, 33.4% of students were anemic, of which 25.8% were mildly anemic, 7.2% were moderately anemic, and 0.5% were severely anemic [6]. Eating habits affect our health as the trend is changing from natural food to processed and junk food, especially in the young generation; nutritional disorders are also increasing. University-going students are the reflection of our younger community; knowing about iron deficiency is important for them to improve their lifestyle and eating habits, which will help them to prevent such nutritional disorders. This research was done to assess the i) iron-related nutritional adequacy of university students and ii) a Hemoglobin test was done to check the levels of Hemoglobin and identify the prevalence of iron deficiency causing iron deficiency anemia among graduates.

Materials and Methods

Study Design

It was a cross-sectional study that included dietary analysis by the survey and biochemical and anthropometry analyses. For evaluating the above-mentioned nutritional disorder, targeted location, gender, and age group selection are essential for the beginning of the research. For that purpose, the age group selected was 18 to 25. Different public and private sector universities of Lahore were selected. The number of samples chosen was 100. Twenty students were from each university; ten were male, and the other ten were female. The data collection technique was simple random sampling, as we had taken a small random portion from the entire population selected after implementing exclusion criteria. As far as inclusion criteria were concerned, the study population was male and female students between 18 to 25 years old. The exclusion criteria selected were any individual having medical complications like cardiovascular disease, hypertension, or any other gastrointestinal tract disorder. Or any female who was pregnant was not allowed to be part of the study.

Research Tool

Questionnaire

A questionnaire having different sections comprising both open and close-ended questions was designed to get the maximum dietary data from participants. Association tests were also checked on the different sections of the questionnaire.

Screening Tool

Body Mass Index (BMI)

Body Mass Index (BMI) is used as an indicator to determine the nutritional status of participants. National Health Service (NHS) UK described the BMI formula as a person's weight divided by the squares of its height in meters.

$$\frac{Weight\ in\ kg}{Height\ in\ m^2} \quad (1)$$

Categories of BMI

There are some categories of BMI. National Health Service has provided these categories [7]. People having BMI lower than 18.5 are considered underweight and vulnerable to developing nutritional deficiencies. Those with BMI between 18.5-24.9 are considered healthy and have less chance of developing any metabolic disorders. Having BMI ranging from 25.0 to 29.9 are indicated as a pre-obesity stage. Such individuals are at risk of developing chronic health disorders. Moreover, obesity follows three steps—stage I, II, and III.

Hemoglobin Test

This test was used to measure the levels of Hemoglobin. Hemoglobin in the blood as it's a protein in blood circulation, and abnormality of its levels in the blood causes low red blood cells that lead to iron deficiency anemia. Healthy hemoglobin levels include 13-16.5g/dL for adult males and 12-16g/dL for adult females (non-pregnant) [8].

Types of Iron Deficiency Anemia

Iron deficiency is categorized into three categories: mild (10-11g/dL), moderate (7-9.9g/dL), and severe <7g/dL).

Data Analysis

Data analysis was done using SPSS's latest version after consultation with a statistician. The p-value was calculated, and a value <0.050 will be considered significant. Appropriate statistical test was applied for different variables analysis, and data was presented with the help of tables, charts, and graphs where necessary.

Limitations

The research was limited to the only universities located in Lahore, Pakistan.

De Limitations

The study was delimited to male and female students aged 18-25 years studying in universities located in Lahore.

Results and Discussion

Questionnaire

As the evaluation of dietary habits is essential, a questionnaire was used. A proper questionnaire was designed

to keep in mind the status of the study. The questionnaire comprises personal history, medical history, knowledge about iron deficiency, and dietary history. Among participants, 63% were not having any food allergies, including male and female students. In comparison, 24% had food allergies. Most of them were female having allergic to milk or egg, and about 2% were allergic to cheese. While filling out the questionnaire, some were told to feel discomfort or nausea while consuming the foods they were allergic to. About 37% of students claimed that they had a family history of iron deficiency; either their mother was Iron deficient or any of their siblings, some said they recovered from their fault, while the majority said that, still, those members are Iron deficient. 26% said they are sure they do not have any family history of iron deficiency. While 37% said they were unsure about it, most were male students, and some were females living in the hostel so that they might know about it. 18% of students had dust allergies. 91% of the students in the study had good knowledge about iron deficiency, while 9% were unaware. Furthermore, 14% think they are Iron deficient, while 43% said they are sure not to have iron deficiency. They said they are Iron deficient or maybe not. On asking about previous blood test reports, 68% of the participants have already done them, while 32% have not done any blood test before **(Figure 1)**.

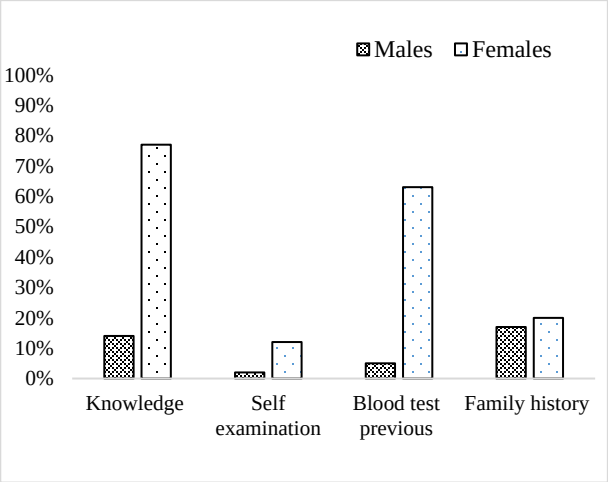

Figure 1. Questionnaire response (%) between male and female groups

Iron deficiency anemia (IDA) is a nutritional disorder mainly caused by a deficiency of essential mineral iron. To access more knowledge about iron deficiency, it was asked from each of them give an opinion about the cure for this disease by consuming iron-rich foods or using supplements to cure it. Therefore, 71% said that a deficiency could be fixed by consuming iron-rich foods, while 27% said that could happen as they were not sure about it. On the other hand, only 2% said no, a deficiency could not be cured only by including iron-rich foods in their diet. For dietary assessment questions regarding different foods, consumption was asked from each of them. Among grains, firstly chapatti and then rice are the staple forms used.

Furthermore, paratha naan and bread are also forms to consume in grains. According to the data collected from students, the consumption of grains among females was 88% meanwhile for males, 95%. Meat, fish, and poultry are among the good sources of Iron and the source of protein too 90% of the male students consume meat products regularly in their diet, while in females, only 40% consume meat products. It comes towards fruit consumption as it contains many vitamins, especially vitamin C, which enhance iron absorption. According to the data collected, 33% of males and 44% of females consume fruits in different forms in their diet. Vegetables can be as raw as salads or cooked as a main dish or side dish; about 22% of males consume vegetables, while in females, it was 40%. Among dairy products, the primary forms include milk, yogurt, and cheese consumption among males was about 45%, while in females, it was just 22% **(Figure 2)**.

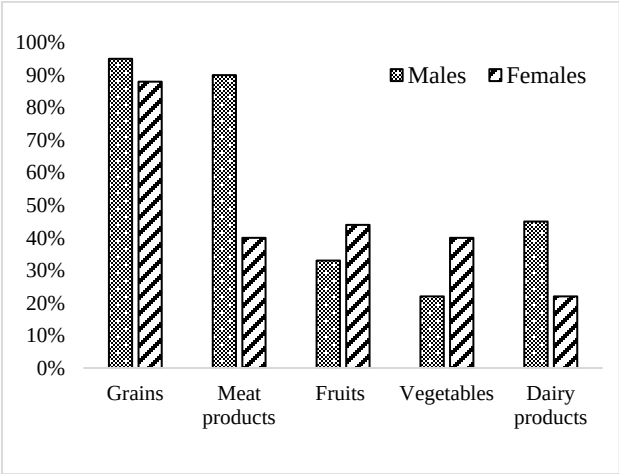

Figure 2. Total Food consumption percentages (%) between male and female groups

Screening Tool

Body Mass Index (BMI)

According to the data collected and calculated from the standard BMI formula, about 2% of male and 32% of female students were underweight. Most students among both genders were 46% males and 54% females. Males were found to be pre-obesity more in numbers than females. About 28% of males were in the stage of pre-obesity and can later turn to phase I if not controlled on time. In females, 8% of females were found in the stage of pre-obesity. Moreover, in males, 14% of students were in obesity stage I, 6% in stage II, and 4% in stage III. On the other hand, in females, 6% were found in obesity stage I while none of the females were found to have obesity of stage II, III **(Figure 3)**.

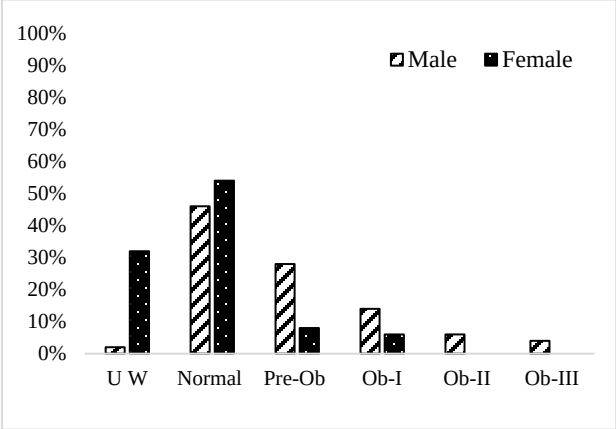

Figure 3. BMI percentages (%) of male and female students (UW=underweight; Ob=Obesity)

Laboratory Analyses

Hemoglobin Test

Hemoglobin is an iron-rich protein in red blood cells (RBC). Its normal levels in the blood are essential as it carries oxygen to the body. Low levels of HemoglobinHemoglobin in the blood indicate iron deficiency. Normal levels of Hb is different for both male and female. For adult males, normal levels are 13 – 16.5 g/dL. For adult non-pregnant females normal level range is 12- 16 g/dL. Iron deficiency is divided into three main categories: mild, moderate, and severe. If the hemoglobin level is 10-11 g/dL, it shows mild lack. If levels are 7-9.9 g/dL, the person has a mild deficiency. Lastly, if levels are <7 g/dL, the person is diagnosed with severe iron deficiency, also called iron deficiency anemia. Separate tables are made for both males and females to identify the values. According to the results of male students, about 90% were found nonanemic after the test. About 10% were found to have a mild deficiency, and none had a moderate or severe weakness. According to the results of female students, 36% were found nonanemic. In contrast, 40% were found to be mildly anemic. On the other hand, 14% have a moderate deficiency, and 10% of the students have severe iron deficiency **(Figure 4)**.

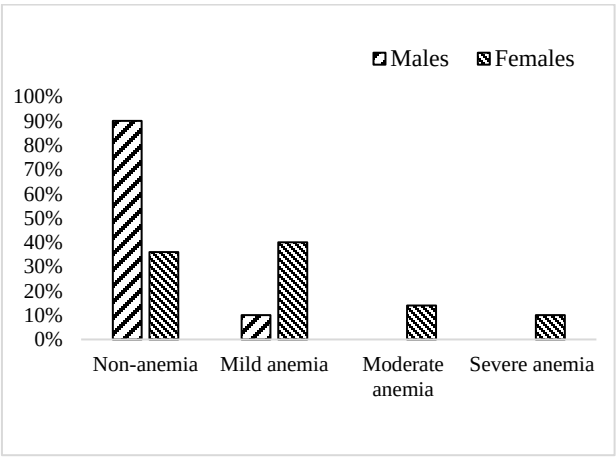

Figure 4. Hemoglobin test percentage (%) of male and female

Association Tests for Iron Deficiency

Association of Iron Deficiency with Body Mass Index

Statistical analysis revealed a significant association (P = 0.032; likelihood ratio) of iron deficiency with an individual's nutritional status. Furthermore, Cramer's V test value (0.304) clarified that iron deficiency was very strongly related to the nutritional status (BMI) of an individual **(Table 1)**. It was noticed that severe iron deficiency prevailed among under-weight and normal subjects concerning their nutritional status. It is worth mentioning that most severely anemic individuals were under-weight, corresponding to 80% of the total severely anemic participants, followed by subjects having normal BMI (20%).

Association of Iron Deficiency with Gender

Statistical analysis revealed a significant solid association (P= 0.000; likelihood ratio) of iron deficiency with gender **(Table 1)**. Furthermore, it was observed by Cramer's V test that iron deficiency was highly related to gender. Moreover, it found that iron deficiency highly prevails among females.

Association of Iron Deficiency with Food Adequacy

Analysis revealed no association (P= 0.111; likelihood ratio) between iron deficiency and food adequacy. Moreover, Cramer V's test elaborates that iron deficiency is strongly related to food adequacy. It was observed that individuals having nonfood adequacy were found anemic in different stages (69%) **(Table 1)**.

Table 1. Association tests for iron deficiency

Parameter	Statistical value	Phi-Value	Cramer's V
Nutritional Status (BMI)	LR = 26.602 P= 0.032	0.527	0.304
Gender	LR = 35.836 P= 0.000	0.552	0.552
Food Adequacy	LR= 6.015 P= 0.111	0.211	0.211
Family History	LR= 7.727 P= 0.259	0.278	0.197
Food Diversity	LR= 4.080 P= 0.253	0.190	0.190

LR= Likelihood Ratio; *= Significant (P< 0.05); **= Significant (P<0.01); NS = non-Significant

Association of Iron Deficiency with Family History

Statistical analysis revealed no significant association (P= 0.259; likelihood ratio) between iron deficiency with family history. Furthermore, Cramer's V test clarified that anemia is strongly related to family history. It was noticed that individuals with a family history of iron deficiency were also diagnosed with iron deficiency at different stages compared to those with no family history of iron deficiency **(Table 1)**.

Association Tests for Food Consumption and Iron Deficiency

Association of Iron Deficiency with Cereals

As cereals are an essential part of our diet, different cereals' consumption associations were checked statistically. The likelihood ratio test showed slight significant association (P= 0.041) between calcium status and rice consumption. Furthermore, it was observed that rice consumption was positively related, which means a person who consumes rice daily has less chance of iron deficiency. Moreover, the consumption of chapatti showed a strong relationship between the variables (Cramer's V = 0.214). On the other hand, the consumption of paratha showed a strong relationship between the variables (Cramer's V=0.193). Lastly, naan consumption also showed a strong relation (Cramer's V= 0.157) **(Table 2)**. Overall, it was observed that all mentioned cereals (grains) were found to have a strong positive relation with iron status. It showed that if an individual consumes cereals daily, then there are fewer chances of developing iron deficiency.

Association of Iron Deficiency with Fruits and Vegetables

Overall, the fruit consumption association was checked statistically. The likelihood test showed no significant association (P=0.529) between iron status and fruit consumption. The strength of the association between iron status and fruit consumption was estimated by Cramer's V test, which showed a value of 0.158, which reveals a strong relationship between iron status and fruit consumption **(Table 2)**. Furthermore, it was observed that fruit consumption was positively related, which means a person who consumes fruits daily has less chance of Iron deficiency **(Table 2)**.

Vegetable consumption was also checked statistically. The likelihood ratio test showed no significant association (P=0.381) between iron status and vegetable consumption. The strength of the association between iron status and vegetable consumption was estimated by Cramer's V test, which showed a value of 0.172, which reveals a strong relationship between iron status and vegetable consumption **(Table 2)**. Moreover, it was observed that vegetable consumption was positively related, which means a person who consumes vegetables daily has less chance of Iron deficiency **(Table 2)**.

Association of Iron Deficiency with Dairy Products

The association of consumption of different dairy products was checked statistically. The likelihood ratio test showed no significant association (P= 0.076) between milk and iron status. Cramer's V test estimated the strength of the association between iron status and milk consumption. It showed a value of 0.211, revealing a robust relationship between iron status and milk consumption **(Table 2)**. Furthermore, it was observed that milk consumption was positively related, meaning a person who consumes milk daily needs to increase the iron intake in his diet to prevent Iron deficiency. Moreover, yogurt consumption showed a moderate positive relationship between the variables (Cramer's V =0.140). On the other hand, cheese consumption showed a strong positive relationship between the variables (Cramer's V= 0.151). Overall, it was observed that all mentioned dairy was found to have a robust positive relation with iron status at different levels. It showed that if an individual consumes dairy products daily, then there are fewer chances of developing Iron deficiency.

The association of egg consumption was checked statistically. The likelihood ratio test showed no association (P= 0.478) between iron status and egg consumption. Cramer's V test estimated the strength of the association between calcium status and egg consumption. It showed a value of 0.173, revealing a robust relationship between iron status and egg consumption **(Table 2)**. Furthermore, it was observed that egg consumption was positively related, which means a person who consumes eggs daily has less chance of iron deficiency **(Table 2)**.

The association of chicken consumption was also checked statistically. The likelihood ratio test showed strong significant association (P= 0.004) between iron status and chicken consumption. Cramer's V test estimated the strength of the association between iron status and chicken consumption. It showed a value of 0.325, revealing a solid relationship between iron status and chicken consumption **(Table 2)**. A positive association was found between chicken consumption and iron status, which shows a person who consumes it daily is less likely to have iron deficiency **(Table 2)**. The association of meat consumption, like mutton and beef, was also checked statistically. The likelihood test showed strong significant association (P= 0.000) between iron status and mutton consumption. Cramer's V test estimated the strength of the association between iron status and mutton consumption showed a value of 0.347, which reveals a strong relation between iron status and mutton consumption **(Table 2)**. A positive association was found between the consumption of mutton and iron status, which shows that a person who consumes it daily still needs to improve the diet to prevent iron deficiency.

The likelihood ratio test showed a strong association (P=0.040) between iron status and beef consumption. Cramer's V test estimated the strength of the association between iron status and beef consumption and showed a value of 0.223, revealing a strong relation between iron status and beef consumption **(Table 2)**. A positive connection was also found here with iron status showing that a person consuming beef as a daily part of the diet has less chance of Iron deficiency **(Table 2)**. The association of fish consumption was checked statistically. The likelihood ratio test showed no significant association (P=0.925) between iron status and fish consumption. Cramer's V test estimated the strength of the association between iron status and fish consumption. It showed a value of 0.093, indicating a weak relationship between iron status and fish consumption **(Table 2)**.

Table 2. Association of Iron deficiency with Grains, Fruits, Vegetable, dairy products, Meat, Fish & Poultry

Parameter	Statistical value	Phi Value	Cramer's v
Rice Consumption	LR= 17.515 P= 0.041	0.380	0.220
Chapatti Consumption	LR= 15.205 P= 0.085	0.370	0.214
Paratha Consumption	LR= 12.016 P= 0.212	0.333	0.193
Naan Consumption	LR= 6.931 P= 0.327	0.221	0.157
Fruit Consumption	LR=8.8055 P= 0.529	0.273	0.158
Vegetable Consumption	LR=9.634 P= 0.381	0.298	0.172
Milk Consumption	LR= 15.591 P= 0.076	0.365	0.211
Yogurt Consumption	LR= 7.339 P= 0.602	0.242	0.140
Cheese Consumption	LR= 9.079 P= 0.169	0.257	0.82
Beef Consumption	LR=13.208 P= 0.040	0315	0.223
Egg Consumption	LR= 8.568 P= 0.478	0.300	0.173
Chicken Consumption	LR= 24.212 P= 0.004	0.563	0.325
Mutton Consumption	LR= 29.564 P= 0.000	0.491	0.347
Fish Consumption	LR= 3.784 P= 0.925	0.161	0.093

It was observed that a weak positive relation was found, which shows that even daily consumption of fish does not have any significant change in iron status **(Table 2)**. Concerning iron deficiency among students, a study conducted at Sindh university results of hemoglobin levels shows a deficit found in both males and females. Males were found to have a mild deficiency, whereas, in females, lack was found from the mild to the moderate stage [9, 10]. The results of that study were correlated with this study as in this current study, the deficiency was found in both males and females at different rates. Males were likely to have developed weakness in the mild to moderate stage, while in females, it was in the soft, intermediate, and even severe stages. Poor dietary patterns are the leading cause of nutritional disorders like iron deficiency. Furthermore, about 18.2% of students consume chicken daily, mainly in the fried form. It is one of the causes of obesity and overweight found by body mass index (BMI) in males. About 28% were diagnosed as pre-obesity, 14% in obesity stage I, 6% in stage II, and 4% in stage III.

A cross-sectional study was conducted on both male and female Saudi university students. According to the results, most male students were nonanemic and had normal hemoglobin levels. Only four were found anemic. Furthermore, female students were found more in the number who were anemic. 67.35% of students had hemoglobin levels less than 12.0g/dl. Among them, 26.54% were anemic females with low serum iron and serum ferritin levels, which directly indicated an iron deficiency [11]. People with this deficiency have many symptoms, categorized into three forms: widespread, frequent, and rare. Symptoms include frequent paleness of skin, conjunctiva, and nail beds, fatigue, laziness, and headache. Symptoms include in frequently are, dry and rough skin along with damaged hairs, heart murmurs, and dizziness. Symptoms include, in rare cases, abnormal blood flow and heart rate, fainting, spoon-shaped nails, and difficulty swallowing [5]. Iron produces Hemoglobin. Hemoglobin through erythroblasts. If the supply of Iron is insufficient in the body, Hemoglobin will not produce; ultimately, levels of red blood cells will decrease, and if this condition stays longer, it will be anemia [12]. A reliable indicator of iron deficiency is the levels of Hemoglobin (Hb) in our blood. World Health Organization (WHO) has defined the standard levels of Hemoglobin. Hemoglobin, for non-pregnant females (15 years and over) as 120gm/L and males (15 years and over) as 130gm/L. Iron deficiency is classified into three stages: Mild, marginal, and Iron deficiency anemia [13]. A study was conducted at Nepal University to check the prevalence of iron deficiency among male and female students. Blood tests were done, and a questionnaire was part of that. The findings of the research elaborate that out of a total of 42.1%, males were mildly anemic, and 11.6% had moderate anemia on the other side; among females, 1.8% were severely anemic, 9.1% were moderately anemic, while 41.8% were mild anemic [14]. In a university of Yemen, a study was conducted to check the level of prevalence among the age group 17 to 25 years in both male and female, for that blood samples were. Questionnaires were filled out by the students themselves based on dietary intake. According to the outcomes, 30.4% of the students were anemic, among whom 47.1% were females, while among males were 21.5%. The prevalence was high in females due to their poor dietary intake compared to males. Out of all, the prevalence rate can have been viewed according to the age group, so the highest rate was in 20-22 years, 59.2% [15]. In Pakistan, iron deficiency is one of the nutritional disorders which is getting peak day after day. As in Kashmir, the prevalence among non-pregnant females is 25%. A study was conducted on females, including young adults in the Muzaffarabad division. The sample size was more than 1500 females. All pretested interviews included questions about socioeconomic status, nutrition, and cultural norms. Anthropometric measurements and blood samples were taken for the Hb test. 52.1% of respondents found nonanemic, and 47.9% found anemic. Of the identified cases, 20.4% had a mild deficiency, 24.8% moderate, and 2.7% severe [16]. This study highlights well as warns about the high prevalence of iron deficiency.

Conclusion

The purpose of this research was to examine the connection between low iron stores and ID, a condition that can manifest itself in its early stages or progress into iron deficient anemia (IDA). Young adults' low iron levels can be explained by the connection between these foods: grains, protein, dairy, veggies, and fruits. An investigation into the connections between gender, body mass index, family history, food variety and sufficiency, food consumption, and iron deficiency was also conducted. Low iron levels in the body from poor eating habits and a diet low in iron-rich foods lead to iron deficiency anemia, which must be treated promptly to prevent the development of chronic health problems. It is quite conclusive that dietary interventions are operational in the treatment of iron-deficiency anemia.

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ETHICS STATEMENT: Ethical consideration was the most crucial part while the research was conducted; data collected from students was kept confidential and was not used for any other purpose, and consent was obtained from all the participants.

References

1. Zhu J, Huang Q. Nanoencapsulation of functional food ingredients. Adv Food Nutr Res. 2019;88:129-65.
2. Darnton-Hill I, Webb P, Harvey PW, Hunt JM, Dalmiya N, Chopra M, et al. Micronutrient deficiencies and gender: social and economic costs. Am J Clin Nutr. 2005;81(5):1198S-205S.
3. Ringoringo HP. Prevalence of Iron Deficiency Anemia and Reference Range of Complete Blood Count, Reticulocyte Parameters in Infants Aged 9–11 Months. Int J Gen Med. 2022;15:8017-24.
4. Miller JL. Iron deficiency anemia: a common and curable disease. Cold Spring Harb Perspect Med. 2013;3(7):a011866.
5. Lopez A, Cacoub P, Macdougall IC, Peyrin-Biroulet L. Iron deficiency anaemia. Lancet. 2016;387(10021):907-16.
6. Jawed S, Tariq S, Tariq S, Kamal A. Frequency of nutritional anemia among female medical students of Faisalabad. Pak J Med Sci. 2017;33(2):398.
7. NHS choices. NHS; [cited 2023Feb8]. Available from: https://www.nhs.uk/common-health-questions/lifestyle/what-is-the-body-mass-index-bmi/
8. Jewell T. Hemoglobin (HGB) test results [Internet]. Healthline. Healthline Media; 2019 [cited 2023Feb8]. Available from: https://www.healthline.com/health/hgb
9. Laghari ZA, Baig NM, Memon F, Panhwar F, Qambarani MR, Palh ZA. Correlation of BMI and MUAC with anemia among Sindh University Students, Jamshoro, Pakistan. Sind Univ Res J-SURJ (Sci Ser). 2017;49(3):553-6.
10. Alkdede MJ, Binsaeed AA, Alameer WH, Alotaibi AA, Alosaimi AS, Alsugair MM, et al. Iron deficiency anemia, diagnosis, and treatment in primary health care center. Arch Pharm Pract. 2020;11(3):122-6.
11. Hamali HA, Mobarki AA, Saboor M, Alfeel A, Madkhali AM, Akhter MS, et al. Prevalence of anemia among Jazan university students. Int J Gen Med. 2020;13:765-70.
12. Milman N. Anemia—is still a major health problem in many parts of the world! Ann Hematol. 2011;90(4):369-77.
13. Coad J, Conlon C. Iron deficiency in women. Curr Opin Clin Nutr Metab Care. 2011;14(6):625-34.
14. Yadav R, Ghimire N, Mukhopadhyay S, Yadav SK. Prevalence of anemia among medical students of Nobel Medical College and correlation with body mass index. Asian J Med Sci. 2020;11(3):62-6.
15. Al-alimi AA, Bashanfer S, Morish MA. Prevalence of iron deficiency anemia among university students in Hodeida Province, Yemen. Anemia. 2018; 2018:1-7.
16. Habib N, Abbasi S-U-RS, Aziz W. An analysis of social determinant of anemia among adolescent girls in Azad Jammu and Kashmir, Pakistan. Anemia. 2020; 2020:1-9.