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Research Article

Assessment of Iron Status among Women of Low and Lower Middle Income Households

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Abstract

Iron deficiency anemia (IDA) is a major public health problem in India affecting developing countries with devastating consequences for human health and socio-economic development. Therefore a study was planned to assess iron status among women of low and lower middle income households and to determine blood hemoglobin level of adult women from two age groups i.e. 15-30 y and 31-45y (50:50) from Balachaur town of district Nawanshahr, Punjab. Information regarding dietary pattern, menstrual cycle, food intake and food consumption frequency of the selected subjects and blood haemoglobin level of the subjects was assessed. Blood iron status was slightly better in younger group in terms of higher MCV and MCH (p = 0.098 and 0.071). Higher intake of polyphenols from tea consumption in the subjects was significantly but negatively (p = -0.208, -0.195 and -0.211) correlated with blood hemoglobin, PCV and MCHC of the subjects. Higher intake of phytates was associated with lower MCHC (r = -0.210). Unsatisfactory iron status in women of reproductive age group is the primary factor of iron deficiency anaemia. Iron status of women (15-45y) from low and lower middle-income households was inadequate due to poor diet quality, and iron-deficiency anaemia is a more serious problem among women of reproductive age. Food fortification can be a beneficial approach because it is a long-term and cost-effective strategy, and governments should prioritize iron supplementation for all women of reproductive age.

Keywords: Ascorbic Acid; Hemoglobin; Iron deficiency Anaemia; Fortification; Polyphenols; Phytates

Introduction

Malnutrition in developing countries involves a spectrum of deficiencies of which, the most prominent is the deficiency of iron. It contributes a great deal of morbidity and ill health, growth retardation, poor development activity in children and lesser productivity in adults. In India, there is widespread occurrence of Iron Deficiency Anemia (IDA). Anemia is a major public health problem which is affecting the developing countries with devastating consequences for human health and socio-economic development. IDA affects all age groups but is highly prevalent in women and young children. As per WHO report, women between the ages of 15 and 49 worldwide have anemia prevalence of 29.9 percent in 2021. In non-pregnant women of reproductive age, the prevalence was 29.6 percent, while in pregnant women, it was 36.5 percent [1]. As per Global Nutrition Reports (2016), India ranks 170 out of 180 countries for anemia among women [2]. It was reported that blood haemoglobin levels were below normal in 50.64 percent of mothers and 55.77 percent of children, the findings imply that iron deficiency anemia prevalence was relatively high in the Punjabi population. According to NFHS III (2007), when dietary intake of iron is insufficient to meet physiological demands, nutritional iron deficiency occurs and this results in anemia. It was also reported, given that the diets of low socio-economic Indian communities were mostly plant-based (rice, pulses, and vegetables) with high amounts of phytic acid, studies of dietary iron consumption in these groups have shown that the intake was lower than the required [3]. Iron bioavailability is primarily influenced by dietary inhibitors like calcium, phytates and polyphenols as well as enhancers like ascorbic acid and proteins. According to FAO/WHO (2002), the effect of factors enhancing iron absorption (ascorbic acid and organic acids; meat, chicken, fish and other seafood; fermented vegetables, fermented soy sauce) compared to factors inhibiting iron absorption (phytates and inositol phosphates; iron-binding polyphenols; calcium; soy, egg and vegetable proteins) determines how much non-heme iron is absorbed from a meal [4]. So this study was planned to assess iron status among women of low and lower middle income households and to determine blood hemoglobin level of adult women from the selected households.

Materials and Methods

Dietary survey

Sample selection

Balachaur, district Nawanshahr, Punjab was selected to conduct the dietary survey. Balachaur is 20.7 km distance from Nawanshahr. It is 70.2 km distance from the state capital Chandigarh. One hundred non-pregnant and non-lactating women from low-income households with annual income less than Rs. 70,069 and equal number of women from lower-middle income households with annual income between Rs. 70,137 to Rs. 2,73,098 from two age groups i.e. 15-30 y and 31-45y (50:50) were selected purposively from Balachaur town of district Nawanshahr, Punjab as per the income classification given by The World Bank (2019). A prior written consent of the subjects to participate in the study was obtained.

Development and validation of questionnaire for assessing dietary intake

An interview schedule was prepared to gather information regarding dietary pattern, menstrual cycle, food intake and food consumption frequency of the selected subjects. The information regarding consumption of jaggery, its source of procurement and its use in various food preparations by the subjects was also obtained. Pre-testing of the interview schedule was carried out on 10 percent of the subjects to check its validity.

Dietary assessment

The data was collected in the month of September, October and November 2021. The daily food intake was determined by 24 Hour Recall method for three consecutive days. General information of the subjects such as age, type and size of family, education, occupation, and family income was collected from the subjects by interview method. Information regarding dietary habits such as vegetarian, non-vegetarian and ova- vegetarian and number of meals consumed per day by the subjects was also collected. The subjects were asked regarding the consumption frequency of food items namely cereals, pulses, green leafy vegetables, roots and tubers, other vegetables, fruits, milk and milk products, sugar, jaggery and honey. The average score of each food group was calculated. The food intake was compared with the suggested intakes given by ICMR (2011) [5]. The nutrient intake was determined using Diet Cal software (Kaur, 2014) [6]. The daily intake of macronutrients i.e. energy, protein, carbohydrates and fats was assessed. The daily intake of iron and other related nutrients and anti-nutrients such as ascorbic acid, beta carotene, calcium, zinc, polyphenols and phytates was also determined. The percent adequacy of nutrients was calculated by comparing their intake with Estimated Average Requirements (EAR)/Recommended Dietary Allowances (RDA).

Blood collection and analysis

Red blood cell number, volume and hemoglobin content was determined by passing a thin stream of anticoagulant-treated blood through a device equipped with optical and electric impedance sensors. Coulter counters measure RBC parameters such as hematocrit and hemoglobin concentration. Complete Blood Count (CBC) of the subjects was done to determine haemoglobin (Hb), Packed Cell Volume (PCV), Mean Corpuscular Volume (MCV); Mean Corpuscular Hemoglobin (MCH) and Mean Corpuscular Hemoglobin Concentration (MCHC). Two millilitre of blood was drawn from vein in the arm of the left hand with syringe and the blood was collected in a vial. The collected sample was then placed in automated cell counter and through electrical impedance, the cell volume and count was given by the cell counter. The Beckman coulter method of counting and sizing was used in combination with an automatic diluting and mixing device for sample processing and a single beam photometer was used for hemoglobinometry to derive CBC parameters.

Data analysis

Mean and standard errors for various parameters were computed. Paired t-test was employed to assess the difference of various parameters in two age groups of selected women.

Results and Discussion

Iron Blood parameters

The subjects (n =100) were divided into two groups on the basis of their age, i.e. Group I (15-30y) and Group II (31-45y). Blood hemoglobin (Hb), Packed Cell Volume (PCV), Mean Corpuscular Volume (MCV), Mean Corpuscular Hemoglobin (MCH) and Mean Corpuscular Hemoglobin Concentration (MCHC) of the subjects was assessed (Table 1). The blood hemoglobin level of the subjects ranged from 7.5 to 14.5 g/dl with a mean value of 10.44 g/dl in Group I, while in Group II, the hemoglobin of subjects ranged from 7.2 to 14.2 g/dl with a mean value of 10.35 g/dl. The average hemoglobin values of the subjects were unsatisfactory when compared with the reference value of 12 g/dl or more (WHO 2011). On the basis of WHO classification of anemia, it was observed 18, 58 and 8 percent of the subjects in Group I were mildly, moderately and severely anemic, the corresponding values in Group II were 14, 64 and 4 percent, respectively. Only 16 and 18 percent were non-anemic in the two groups, respectively (Fig. 1). The high incidence of anemia among the women from low and lower middle-income groups is a matter of great concern. A study conducted in Punjab reported that hemoglobin levels of women ranged from 8.3 to 12.4 g/dl, with a mean value of 10.5 g/dl and the mean hemoglobin level was found to be unsatisfactory as 83 percent of the subjects were found to be anemic [7]. The results of the present study were similar to the reported study. On the other hand it was reported that, the mean blood hemoglobin level of low-income rural Punjabi women was 10.4g/dl, with iron deficiency anemia prevalence of 50.6 percent in the studied group[8]. The Packed Cell Volume (PCV) of the subjects in Group I and II ranged from 30.9 to 53.4 percent and 30.9 to 54.3 percent with a mean value of 38.3 and 38.54 percent, respectively. When compared to the normal range of 36.1 to 44.3 percent of PCV, the values were satisfactory but towards the lower margin. For Group I, the MCV of subjects ranged from 75.3 to 116.3 fl with a mean value of 91.0, while for Group II, the MCV of subjects ranged from 71.9 to 120.3 fl with a mean value of 88.0 fl. When the mean values of both the groups were compared with normal range of 80-100 fl, these were found to be acceptable. The MCH of subjects ranged from 22.4 to 37.6 pg with a mean value of 28.39 ± 3.13 pg, while for Group II, MCH of subjects ranged from 20.3 to 38 pg with a mean value of 26.97 pg. The mean MCH of both the groups was acceptable as it was within the normal range (27-32 pg), it was also found to be acceptable in Group I but the subjects in Group II had a significantly (p = 0.098) lower MCH in comparison to Group I. The MCHC of the subjects in Group I ranged from 22.9 to 34.4 g/dl with a mean value of 30.37 g/dl, while in Group II, the MCHC ranged from 27.1 to 32.9 g/dl with a mean value of 31.03 g/dl, which was found to be higher. The MCHC was found to be below the normal range of 32 and 36 g/dl. The findings revealed that the blood iron status was slightly better in younger group in terms of higher MCV and MCH (p = 0.098 and 0.071), however, overall picture of hematinic blood parameters was dismal among the women belonging to low and lower-middle income households.

Blood Parameter	Group I (15-30y) (n=50)		Group II (31-45y)(n=50)		*P value*	Reference value/Normal range (WHO 2011)
	Range	Mean ± SD	Range	Mean ± SD		
Hb, g/dL	7.5-14.5	10.44 ± 0.38	7.2-14.2	10.35 ± 0.5	0.253^{NS}	≥12.0
PCV, %	30.9-53.4	38.54 ± 2.87	30.9-54.3	38.3 ± 3.13	0.296^{NS}	36.1-44.3%
MCV, fl	75.3-116.3	91.52 ±8.8	71.9-120.3	88.3 ± 8.3	0.098*	80-100
MCH, pg	22.4-37.6	28.39 ± 3.13	20.3- 38	26.97 ± 2.98	0.071*	27-32
MCHC g/dl	27.1-32.9	31.03 ± 3.13	22.9-34.4	30.37 ±1.78	0.223^{NS}	32-36

Table 1: Blood iron status of the selected women belonging to low and lower middle-income households.

Hemoglobin (Hb) Packed Cell Volume (PCV); Mean Corpuscular Volume (MCV); Mean Corpuscular Hemoglobin MCH; Mean Corpuscular Hemoglobin Concentration (MCHC)

^{NS} Non significant; * Significant at 10%

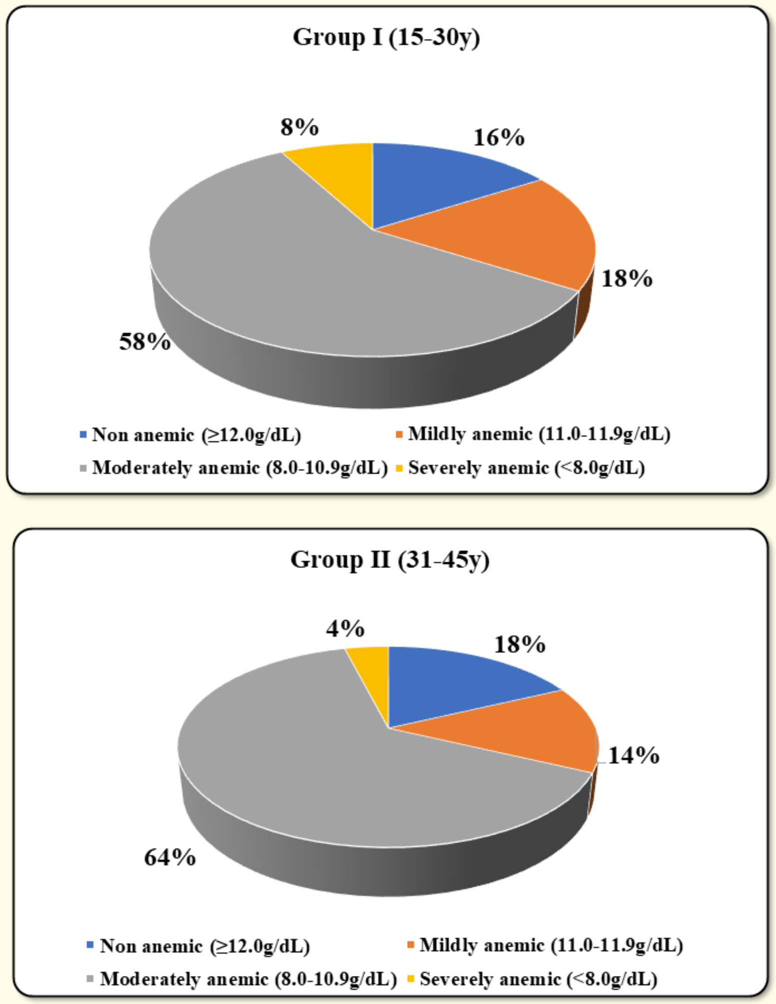

Figure 1: Prevalence of Iron deficiency anemia on the basis of anemia classification (WHO 2011) among selected women (15-45y) belonging to low and lower middle households.

Clinical symptoms

Clinical signs of iron and ascorbic acid deficiency were assessed in terms of paleness of skin, spoon shaped nails, breathlessness on exertion, fatigue and bleeding gums (Table 2). The most prevalent symptom of iron deficiency was fatigue which was reported by 54 and 56 percent of the subjects from Group I and II, respectively. It was followed by paleness of skin among 50 and 42 percent, while breathlessness on exertion was reported by 42 and 48 percent of the subjects in Group I and II, respectively. Spoon shaped nail, a symptom of severe iron deficiency was reported in only 1 percent of the subjects while bleeding gums due to ascorbic acid deficiency was reported by only 3 percent of the subjects. A study on Punjabi women reported that the nail pigmentation was witnessed in 54 percent of women and 64 percent of them got fatigued easily and 44 percent were experiencing frequent headaches [8].

Particular	Group I (15-30y) (n = 50)	Group II (31-45y) (n = 50)	Overall (n = 100)
Paleness of skin	25 (50%)	20 (40%)	45 (45%)
Spoon shaped nails	0 (0%)	1 (2%)	1 (1%)
Breathlessness on exertion	21 (42%)	24 (48%)	45 (45%)
Fatigue	27 (54%)	28 (56%)	55 (55%)
Bleeding gums	1 (2%)	2 (4%)	3 (3%)

Table 2: Clinical signs of iron and ascorbic acid deficiency among selected women belonging to low and lower middle-income households.

Percent adequacy of food groups among the selected women belonging to low and lower income households

Average daily intake of cereals was 152.25 g by women in Group I whilst it was 159.45g in Group II. Wheat was the most commonly consumed cereal by the subjects. When compared to suggested intakes (270g) given by (ICMR 2011), it was found that the average daily intake of cereals by subjects was insufficient. Average daily intake of pulses and legumes was 31.53 g by women in Group I while it was 25.45 g in Group II. The daily intake of pulses and legumes was found unsatisfactory when compared to the suggested intake of 60g. A study among anemic and non-anemic women reported that the daily carbohydrate intake was 141 and 135g [10]. Similarly in the present study, the higher intake of carbohydrates and lower intake of proteins by the subjects in the present study showed a poor quality diet of women from low income households. The consumption of green leafy vegetables was found to be extremely low among the subjects in Group I. Only 12 percent of women in Group I consumed green leafy vegetables and that too in small quantities. The daily intake of green leafy vegetables in Group I and II was 12.82 g and 74.78g. The intake of Green leafy vegetables in Group I was significantly ($p \leq 0.001$) lower than Group II in comparison to Group I. The daily intake of other vegetables was unsatisfactory when compared to suggested daily intake. The daily intake of roots and tubers was also inadequate. According to a study, the Punjabi farm women consumed 65.4 g of green leafy vegetables on a daily basis during winter season, when there is a plentiful supply of iron-rich leafy vegetables but this was contrary to the present study.

Fruits were consumed only by 28 percent of the subjects. The daily intake of fruits by Group I women was 52.22 g while by Group II, it was 48.57 g and was less than the suggested intake of 100 g. The average daily intake of milk and its products by women in Group I was 311.75 g whereas, its intake by Group II was 181.50 g. It was observed in a study on Punjabi women that there was negligible fruit intake (15.7g) by the rural low-income women which was very similar to the present study[7]. Similarly it was stated in a study that the fruits were consumed in negligible quantities because the majority of the subjects came from low-income families[9]. The subjects in Group I consumed significantly ($p \leq 0.001$) more milk and its products in comparison to Group II. The daily intake of fats and oils in Group I women was 29.59 and 29.13g in Group I and II, respectively. The average daily intake of sugar and jaggery by women in Group I was 27.25g whereas, its intake in Group II was 18.19g. The subjects in Group I consumed significantly ($p \leq 0.001$) more sugar and jaggery in comparison to Group II. White sugar intake was more prevalent while jaggery consumption was less. Sugar was mostly consumed in tea and milk. Percent adequacy of food groups among the selected women belonging to low and a lower income household is as shown in figure 2.

Nutrient Intake

The average daily intake of energy and protein for the subjects in Group I was 1133 kcal and 28.20g whereas, for the subjects in Group II was 1139 kcal and 29.55 g, respectively. The average daily intake of energy and protein was insufficient. The average daily intake of fat for women in Group I and II was more than EAR (20g). Carbohydrate intake was also found to be greater than the EAR/RDA (110g/130g) for Indians. The average daily intake of iron by Group I was 8.18 mg whereas, for the Group II women, it was 8.56 mg. On comparing it with EAR/RDA, iron intake was found be unsatisfactory. Similarity was found in present study and the study

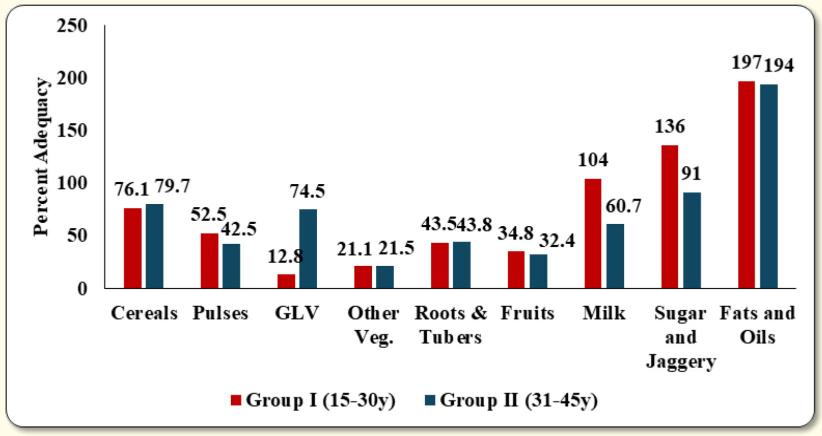

Figure 2: Percent adequacy of food groups among selected women belonging to low and lower middle-income households.

that was conducted on Punjabi women that the total iron intake of rural women from low- income households was 8.07 mg/day [7]. Iron intake in India was less than half of the recommended dietary allowance, with an iron density of about 8.5 mg/1000 kcal [11] and a low intake of iron (17 mg/day) by Punjabi women was also reported [12]. The average daily intake of zinc by Group I and II was 5.60 and 6.11 mg, respectively, the corresponding values for dietary intake of calcium were 379 and 380mg. Both zinc and calcium intakes were inadequate. The results of the present study were closed to the reported study. In a study among the rural women from low-income households it was observed that the average zinc intake was 5.98 mg per day [13]. The average daily intake of ascorbic acid by Group I and II was 26.86 and 29.95mg and was inadequate. The average daily intake of polyphenols by Group I was 48.97 and 62.35mg, respectively. Ascorbic acid intake could be insufficient due to low purchasing power of subjects as lemons and other vitamin C rich fruits were costly at that time which is one of the richest sources of iron, was not consumed by majority of the subjects reported its unavailability. In a study on Punjabi women it was reported that the average daily intake of ascorbic acid was 25.4mg [14]. The low level of ascorbic acid in their meals may have a negative impact on iron absorption. Several literature reports emphasized the beneficial role of ascorbic acid in improving iron status due to its role in absorption of iron [15-17]. The intake of polyphenols probably coming from tea was significantly ($p = 0.006$) higher among the subjects in Group II when compared with the intake of subjects from Group II. The average daily intake of phytates by the subjects in Group I and II was 1010 and 1118mg, the intake was significantly ($p = 0.05$) higher in Group II in comparison to Group I. High consumption of phytate rich foods and low intake of iron absorption promoting foods was the major reason for iron deficiency anemia in these selected women.

Correlation coefficients (r) between blood iron status parameters and inhibitors of iron absorption

On deriving the correlation coefficients (r) between the intake of nutrients and antinutrients and blood iron status parameters, the present study revealed that higher intake of polyphenols that is probably from high tea consumption in the subjects was significantly but negatively ($p = -0.208$, -0.195 and -0.211) correlated with blood hemoglobin, PCV and MCHC of the subjects. On the other hand, higher intake of phytates was associated with lower MCHC ($r = -0.210$). Many studies reported that polyphenols are a class of compounds found in large amounts in beverages such as coffee and tea that are competitive inhibitors of nonheme iron absorption [18,19]. It was observed in a study that tea caused iron bio-accessi-

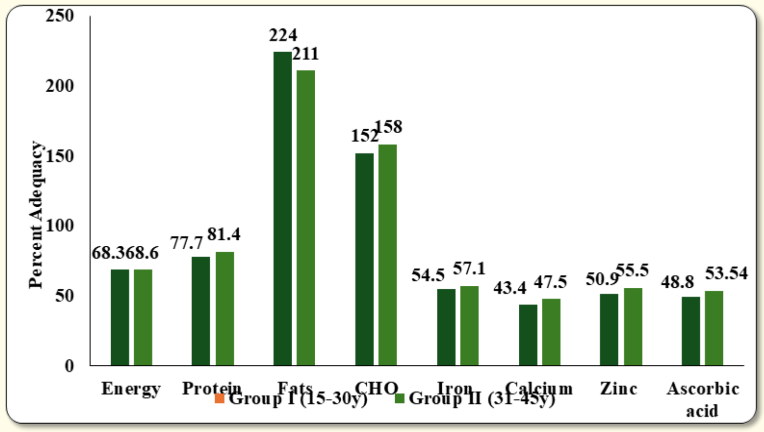

Figure 3: Percent adequacy of nutrients among selected women belonging to low and lower middle-income households.

bility reduction between 21.5 to 55.3 percent therefore; it should be avoided with meals [20]. The current study, as well as previous studies conducted in India and other developing countries, confirmed an unsatisfactory iron status in women of reproductive age group, which is the primary factor of iron deficiency anaemia.

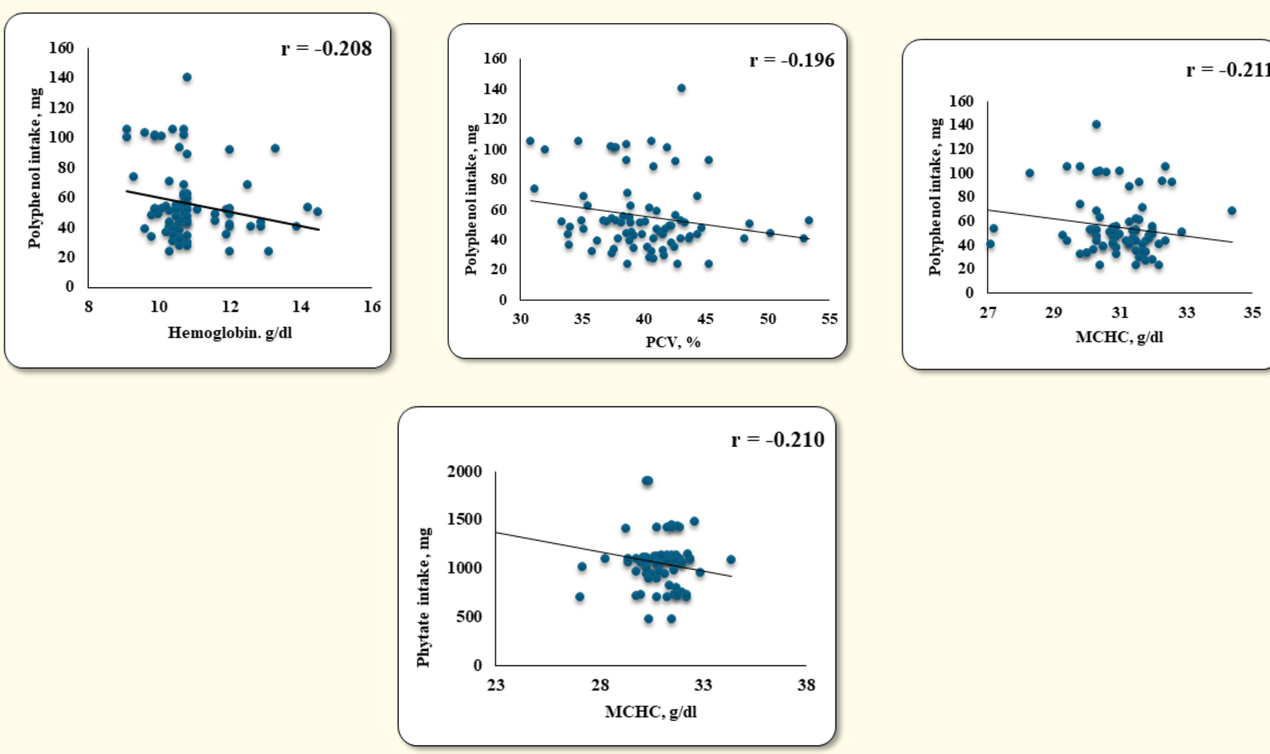

Figure 4: Correlation coefficients (r) between blood iron status parameters and inhibitors of iron absorption.

Conclusion

The study concluded that the iron status of women (15-45y) from low and lower middle-income households was inadequate due to poor diet quality, and iron-deficiency anaemia is a more serious problem among women of reproductive age. It is recommended that the general public be made aware of the importance of iron and ascorbic acid rich foods in preventing iron deficiency anaemia through printed and electronic mass media. Common food fortification with appropriate iron salts can help to prevent this public health problem in developing countries like India. Food fortification can be a beneficial approach because it is a long-term and cost-effective strategy, and governments should prioritise iron supplementation for all women of reproductive age.

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