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Association of Iron Deficiency Anemia with Cognitive and Physical Performance in Women Presenting with Heavy Menstrual Bleeding: A Cross-Sectional Study

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ABSTRACT

Background: Heavy menstrual bleeding is a common gynecological problem and a leading cause of iron deficiency anemia in women of reproductive age. While anemia is routinely identified, its impact on cognitive function and physical performance is frequently under-recognized in clinical practice.

Objective: To determine the association of iron deficiency anemia with cognitive and physical performance in women presenting with heavy menstrual bleeding.

Methods: This hospital-based cross-sectional study was conducted from February 2024 to March 2025 at a tertiary-care hospital. A total of 120 women aged 18–45 years presenting with heavy menstrual bleeding were enrolled through consecutive sampling. Hemoglobin and serum ferritin levels were measured to classify participants into iron deficiency anemia and non–iron deficiency anemia groups. Cognitive performance was assessed using the Montreal Cognitive Assessment, while physical performance was evaluated using handgrip strength and the six-minute walk test. Statistical comparisons and multivariable regression analyses were performed to assess independent associations.

Results: Iron deficiency anemia was present in 58.3% of participants. Women with iron deficiency anemia demonstrated significantly lower cognitive scores and reduced physical performance compared to non-anemic women. Hemoglobin and ferritin levels showed positive correlations with both cognitive and physical performance measures. After adjustment for potential confounders, iron deficiency anemia remained an independent predictor of impaired cognitive function and reduced physical capacity.

Conclusion: Iron deficiency anemia is highly prevalent among women with heavy menstrual bleeding and is independently associated with poorer cognitive and physical performance. Routine screening and timely management of iron deficiency anemia should be integrated into standard care for women with heavy menstrual bleeding to improve functional outcomes.

Keywords: heavy menstrual bleeding; iron deficiency anemia; cognitive performance; physical performance; women

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INTRODUCTION

One of the most frequent gynecological complaints in women of reproductive age and a major cause of iron deficiency in the world is heavy menstrual bleeding (HMB). It is medically characterized as excessive bleeding of menstruation that disrupts the physical, emotional, social, and material quality of life in a woman [1]. Even though patients usually under-report or accept persistent heavy menstrual bleeding, in the long term, such bleeding may lead to severe iron depletion, and finally, turn into iron deficiency anemia (IDA). The nutritional iron deficiency caused by low- and middle-income countries, such as Pakistan, enhances the burden of HMB-related anemia by contributing to the delayed health-seeking behavior and the routine screening [2].

Iron is essential in the formation of hemoglobin, which carries oxygen to the blood vessels and in various neurobiological and muscular functions [3]. Neurotransmitter production, myelin, mitochondrial energy, and muscle functioning all require everyone to have enough iron. Therefore, iron deficiency (especially when it results in anemia) might present outside of the hematological abnormalities, which then causes fatigue, lack of physical stamina, loss of concentration, memory loss, and lack of work productivity. Such functional impairments are of particular concern to women with HMB as they can have chronic iron deficit months or years before their diagnosis [4].

The growing body of evidence indicates that iron deficiency anemia hurts cognitive functioning in adult individuals and affects attention, executive functioning, and speed of information processing [5]. On the same note, low hemoglobin and exhausted iron stores have been linked with low physical performance as indicated by walking capacity and muscle strength. Although these associations have been addressed in some of the populations by the use of selected populations such as adolescents and non-pregnant women, the evidence that specifically addresses women who present with heavy menstrual bleeding in normal hospital practices has little data. The majority of clinical assessments of HMB focus on the definition of the gynecological etiology and management of bleeding and less on the determination of functional outcomes, including cognitive effectiveness and physical capacity [6].

Clinical importance of understanding the relationship between iron deficiency anemia and functional outcomes in women with HMB lies in the fact that anemia is a condition in which the body cannot absorb the iron consumed by women [7]. The effect of cognitive impairment and lower physical activity can significantly influence the daily activities, occupational efficiency, and the overall quality of life, even without significant anemia effects. Earlier detection of these relationships can contribute to more holistic methods of management, combining the iron status evaluation and regular gynecological care [8].

Consequently, the cross-sectional study, which was in the form of a hospital, was aimed at assessing the relationship between iron deficiency anemia and cognitive and physical performance among women who presented with heavy menstrual bleeding. This paper seeks to identify the broader clinical implications of iron deficiency anemia by analyzing the hematological parameters and functional outcomes of iron deficiency anemia in this common-but-frequently-understudied group of patients [9].

MATERIALS AND METHODS

The study was a hospital-based cross-sectional study that sought to determine the correlation between cognitive and physical performance and iron deficiency anemia in women who presented with heavy menstrual bleeding. The study was carried out in the Gynecology Outpatient Department and Emergency department of Quaid e Azam medical college/Bahawal Victoria Hospital (QAMC/BVH), Bahawalpur, Pakistan, a period of fourteen months, between February 2024 and March 2025.

120 women were used in the study. The participants were selected with the help of a non-probability consecutive method of sample selection when all women meeting the eligibility criteria and reporting heavy menstrual bleeding within the study timeframe were approached and recruited until the necessary number of participants was reached. This sampling technique was adopted as it is representative of the clinical presentation in the real world in a hospital.

Women between the ages of 18 and 45 years who brought complaints involving heavy menstrual bleeding over at least the past three menstrual periods were eligible. The presence of heavy menstrual bleeding was determined using the patient-reported excessive blood loss that disrupts the normal activities of the patient, such as frequently changing pads, passing of clots, flooding, or long-lasting bleeding. Only informed consent, which was in writing, was enrolled in the study.

The participants were also excluded in case they were pregnant, less than six months after childbirth, diagnosed with a bleeding disorder or hemoglobinopathy in the past, or had anemia of known non-iron etiology. Chronic systemic diseases like chronic kidney disease, chronic liver disease, malignancy, or inflammatory diseases were also excluded, as they may affect the hemoglobin and ferritin levels. Women diagnosed with neurological or psychiatric conditions potentially to independently affect cognitive functioning independently, and those who had undergone intravenous iron therapy or blood transfusion within the 812 weeks before the study were also excluded as controls to avoid distorting baseline iron status.

The structured proforma was used to gather the data after enrollment. Demographic data such as age, education level, marital status, parity, and occupation were taken. An elaborate menstrual history was also taken, including the cycle length, bleeding duration, pads per day, clot passage, and flooding. Other symptoms linked with this were fatigue, dizziness, palpitations, dyspnea on exertion, pica, and sleep duration. Anthropometric data such as weight and height were taken to determine body mass index, and a spot physical examination was conducted to determine pallor and general clinical condition.

All participants were subject to laboratory studies. The samples of the venous blood were under aseptic conditions, and a complete blood count (including hemoglobin concentration, mean corpuscular volume, mean corpuscular hemoglobin, and red cell distribution width) was conducted with the help of an automated hematology analyzer found in the hospital laboratory. The measurement of iron stores was taken by measuring serum ferritin by use of standard immunoassay techniques. Anemia was determined as a less-than-normal hemoglobin less than 12.0 g/dL in non-pregnant women, an iron deficiency serum ferritin of less than 15 µg/L, and iron deficiency anemia as a combination of a less-than-normal hemoglobin level and serum ferritin.

A standardized cognitive screening test was used to evaluate cognitive performance: the Montreal Cognitive Assessment (MoCA). The test was given under a silent condition through the efforts of trained personnel, and the total scores were registered on a scale of 0 to 30. Education-related adjustments of scores were made where necessary based on the standard recommendations to reduce the bias of education.

There were two objective measures of physical performance. The strength of the handgrip was assessed with a handheld dynamometer with the participant sitting and flexing the elbow at a 90 position and the dominant hand held. The short rest periods were captured three times, and the maximum was taken in analysis in kilograms. The standard six-minute walk test was used to determine functional exercise capacity; the test was done on a marked flat corridor. The participants have been directed to walk at their own speed throughout six minutes, and the distance that is covered in meters was measured.

All the data collected were inputted and analyzed by the use of SPSS software. Continuous variables were reported in the form of mean and standard deviation, whereas categorical variables were reported in frequency and percentages. Appropriate statistical tests were used to compare women with iron deficiency anemia and those without iron deficiency anemia. The analysis was carried out using correlation analysis on the correlation between the level of hemoglobin and ferritin with the level of cognitive and physical performance. The independent relationship of iron deficiency anemia with cognitive and physical performance was established by multivariate linear regression analysis following the adjustment of possible confounding variables of age, education level, body mass index, parity, heavy menstrual bleeding severity, and sleep duration. The p- p-value less than 0.05 was taken to be statistically significant.

The study was ethically approved (QAMC/ERC/GYN/2024/123) by the Institutional Ethical Review Committee before the start of the study. All the participants were informed and gave written informed consent, and their personal information was kept confidential. Respondents with moderate and severe anemia or iron deficiency were advised and referred to seek the proper treatment following the hospital treatment protocol.

RESULTS

One hundred and twenty women who came with complaints of heavy menstrual bleeding were recruited and finally included in the analysis. According to preset hematological and biochemical levels, 70 respondents (58.3%) were diagnosed with iron deficiency anemia (IDA), whereas 50 respondents (41.7%) were diagnosed with non-IDA. The findings are displayed in the form of organized and detailed paragraph interpretation, and the tables are referred to in the text.

Baseline demographic and clinical features.

Table 1 summarizes the demographic and clinical characteristics of the population being studied at the baseline. The mean age of the respondents was 31.2, and the standard deviation of 6.1 years, with no significant difference between the IDA and non-IDA samples in the age group ($p = 0.28$). Those women were mostly multiparous, and parity distribution was not significantly different among the groups. Nonetheless, educational status demonstrated a significant difference: females with IDA were less likely to have 12 or more years of formal education than their non-IDA counterparts (34.3% vs 56.0%, $p = 0.02$).

The severity of heavy menstrual bleeding varied significantly across groups. HMB, moderate to severe, was 65.7 among women in the IDA group versus 44.0 among women in the non-IDA group, reaching statistical significance ($p = 0.01$). There was no significant difference between the two groups in body mass index, and this implied that the nutritional status based on BMI was not likely to confound the observed associations. Table 1 describes these baseline findings.

Hematological and iron status findings: Table 2 shows the hematological and iron profile of the participants. As anticipated, the hemoglobin concentration of women with IDA was much lower, and the mean hemoglobin level was 9.7 ± 1.1 g/dl as opposed to that of 12.6 ± 0.7 g/dl in the non-IDA category ($p < 0.001$). The diagnosis of iron deficiency anemia was also supported by red cell indices, where the mean corpuscular volume and mean corpuscular hemoglobin significantly ($p < 0.001$) decreased in the IDA group.

The serum ferritin concentration was significantly lower in women with IDA, with a median of 8.5 µg/L (IQR 6-12), compared to women without IDA who showed a significantly higher level of serum ferritin concentration of 27.9 µg/L (IQR 18-41, p=0.001). These results confirm that there were depleted iron stores as well as a microcytic and hypochromic anemia pattern in women with IDA, as seen in Table 2.

Cognitive performance outcomes: The assessment of cognitive performance, conducted through the Montreal Cognitive Assessment, demonstrated a substantial difference between women with iron deficiency anemia and those without, as shown in Table 3. The average MoCA score of women with IDA was 21.9 ± 3.3, which was much lower as compared to the average score of 24.8 ± 2.9 in the non-IDA group ($p<0.001$).

Also, a significantly lower percentage of women in the IDA group had low scores below the frequently referenced normal cognitive functioning criterion (MoCA <26). In particular, females exhibiting IDA were found to have cognitive impairment more often than those without IDA 74.3% versus 44.0%, p = 0.001). These results, which are consolidated in Table 3, show that iron deficiency anemia in women with heavy menstrual bleeding correlates with a low level of cognitive performance.

Physical performance outcomes: Table 4 presents physical performance outcomes. Iron deficiency had a substantially lower functional exercise capacity depicted using the six-minute walk test. The IDA group had a mean of 368 ± 60 meters of the six-minute walk distance as compared to 408 ± 55 meters of the non-IDA group (p < 0.001).

On the same note, handgrip dynamometry, which is used to measure muscle strength, gave significantly lower results in women with IDA, with a mean handgrip strength of 19.2 + 4.0 kg when compared to that of women without IDA, 22.1 + 4.3 kg (p < 0.001). The results described in Table 4 demonstrate the negative effect of iron deficiency anemia on physical performance.

Table 1: Baseline demographic and clinical characteristics of participants (n = 120)

Variable	IDA (n = 70)	Non-IDA (n = 50)	p-value
Age (years), mean ± SD	31.7 ± 6.0	30.5 ± 6.3	0.28
Parity ≥2, n (%)	48 (68.6)	28 (56.0)	0.15
Education ≥12 years, n (%)	24 (34.3)	28 (56.0)	0.02
BMI (kg/m²), mean ± SD	26.4 ± 4.5	26.9 ± 4.1	0.56
Moderate–severe HMB, n (%)	46 (65.7)	22 (44.0)	0.01

Table 2: Hematological and iron status parameters of participants

Parameter	IDA (n = 70)	Non-IDA (n = 50)	p-value
Hemoglobin (g/dL), mean ± SD	9.7 ± 1.1	12.6 ± 0.7	<0.001
MCV (fL), mean ± SD	74.2 ± 6.5	84.0 ± 5.4	<0.001
MCH (pg), mean ± SD	23.1 ± 2.4	28.4 ± 2.1	<0.001
RDW (%), mean ± SD	16.8 ± 2.1	13.9 ± 1.5	<0.001
Serum ferritin (μg/L), median (IQR)	8.5 (6–12)	27.9 (18–41)	<0.001

Table 3: Cognitive performance outcomes by anemia status

Cognitive measure	IDA (n = 70)	Non-IDA (n = 50)	p-value
MoCA score, mean ± SD	21.9 ± 3.3	24.8 ± 2.9	<0.001
MoCA <26, n (%)	52 (74.3)	22 (44.0)	0.001
MoCA ≥26, n (%)	18 (25.7)	28 (56.0)	—

Table 4: Physical performance outcomes among participants

Outcome	IDA (n = 70)	Non-IDA (n = 50)	p-value
Six-minute walk distance (m), mean ± SD	368 ± 60	408 ± 55	<0.001
Handgrip strength (kg), mean ± SD	19.2 ± 4.0	22.1 ± 4.3	<0.001

The correlation analysis showed that iron status parameters and functional outcomes had significant positive relationships. The level of MoCA score (r = 0.42, p < 0.001) and six-minute walk distance (r = 0.35, p < 0.001) exhibited moderate positive correlations with the level of hemoglobin concentration. MoCA score (r = 0.30, p = 0.002) and handgrip strength (r = 0.27, p = 0.004) also had a positive correlation with serum ferritin levels.

In multivariate linear regression analysis, iron deficiency anemia was an independent predictor of impaired cognitive and physical performance, even after the adjustment of age, education level, body mass index, parity, intensity of heavy menstrual bleeding, and duration of sleep. IDA was linked with a 2.2-point lowering of MoCA score (95% CI: -3.0 -1.4; p =0.001), a 26-meter decrease in six-minute walk distance (95% CI: -42 -10; p =0.002), or a 2.0 kg decrease in handgrip strength (95% CI: -3.1 -0.9; p =0.001). These modified results support the strength of the relationships in the univariate analyses.

In general, the findings indicate that iron deficiency anemia is very common among women who present with heavy menstrual bleeding. Poor cognitive and physical capacity was constantly related to iron deficiency anemia, even in cases of major confounding factors. The tabular data and analysis indicate good evidence that the impact of iron deficiency anemia on a patient population is not confined to hematological abnormalities, as indicated by the structured tabular data and respective analysis.

DISCUSSION

The study was conducted in the Gynecology Outpatient Department and Emergency Department of Quaid-e-Azam Medical College / Bahawal Victoria Hospital (QAMC/BVH), Bahawalpur, Pakistan indicates that iron deficiency anemia is very prevalent in women who present with heavy menstrual bleeding and gives clear information that iron deficiency anemia is highly linked to poor cognitive and physical functioning in this group [10]. A significant fraction of the enrolled women (more than half) had iron deficiency anemia, indicating the high rate of iron depletion in women with long-term menstrual bleeding. This observation is especially applicable to low- and middle-income environments, where nutritional iron deficiency, late diagnosis, and infrequent screening of individuals only contribute to the clinical consequences of heavy menstrual bleeding [11].

A significant decrease in cognitive functions in iron-deficient anemic women is one of the major results of the study. The woman in the IDA group showed significantly low scores on MoCA, and the proportion of women who had scores that were reflective of cognitive impairment was significantly higher [12]. This was so even though age, level of education, body mass index, parity, sleep duration, and severity of bleeding were taken into account, and showed that iron deficiency anemia has a direct impact on diminished cognitive efficiency [13]. These results are biologically plausible in that iron plays a key role in the synthesis of neurotransmitters, synaptic plasticity, myelin development, and energy metabolism in the brain through mitochondria. Repeated iron loss is thus capable of disrupting attention, executive functioning, and memory, cognitive areas that are often compromised among iron-deprived people. Notably, the mental alterations can be observed even before severe cases of anemia, which implies that it is not hormone concentration itself but iron deficiency that can be critical [14].

The study also showed a strong relationship between iron deficiency anemia with decreased physical performance. Women with IDA also had a distance of six minutes walk and handgrip strength that was significantly lower than that of the women without IDA [15]. The findings suggest reduced functional exercise capacity and muscle strength that are clinically significant outcome measures in relation to daily activities, occupational productivity, and overall quality of life. Low hemoglobin concentrations resulting in reduced oxygen delivery to skeletal muscle, coupled with a decreased oxidative metabolism through iron depletion stores, are possible reasons behind reduced endurance and early fatigability exhibited by anemic women. The positive relationships between hemoglobin, ferritin, and physical performance parameters are also consistent, which contributes to the existence of such a mechanistic relationship [16].

A notable finding during the study is that the extent of heavy menstrual bleeding is strongly associated with the occurrence of iron deficiency anemia [17]. The risk of iron deficiency anemia in women who reported moderate to severe heavy menstrual bleeding was significantly increased, and this supports the idea that chronic, unmanaged menstrual blood loss is a significant cause of iron depletion. Nevertheless, a large number of women attend late, and in most cases, the lateness has been shown to be after long durations of exhaustion, insufficient physical strength, and mental strain, which is often ascribed to stress or daily work routine rather than actual anemia. This underscores the importance of clinicians to probe actively into functional symptoms and not just on gynecological complaints [18].

The results of this study have significant clinical implications. The modern approach to the treatment of heavy menstrual bleeding is usually focused on identifying structural or hormonal etiologic factors and controlling the hemostasis, but the pathophysiology effects of iron deficiency anemia are relatively less prioritized [19]. The findings of this study are that regular hemoglobin and iron stores assessment should be part and parcel of the evaluation of women with heavy menstrual bleeding. Prompt diagnosis and intervention of iron deficiency anemia could not only address laboratory abnormalities but could also result in significant improvements in thinking skills, physical abilities, and general health [20].

There are a number of strengths of this study. It compared the hematological parameters and clinically significant functional outcomes, which gave a detailed analysis of the effects of iron deficiency anemia. Validity of the findings is enhanced by the fact that objective physical performance measures are used, and a standardized cognitive screening tool is used. Also, the observed associations are strengthened by the adjustment of various possible confounders [3,6].

Nevertheless, some shortcomings need to be mentioned. The cross-sectional nature would not be able to be inferred as cause and effect; longitudinal or interventional studies will be required to determine whether the remedy of iron deficiency anemia results in the enhancement of cognitive and physical performance in heavy menstrual bleeding [5]. Although commonly used to measure iron stores, serum ferritin is susceptible to inflammation, and the measurement of inflammatory markers was not always carried out on all subjects. Moreover, cognitive evaluation was conducted using a screening tool as opposed to an elaborate neuropsychological battery that can be used to underestimate subtle cognitive impairments [7].

Nevertheless, the results of the present study form helpful evidence in the perception of the overall clinical effects of iron deficiency anemia in women with heavy menstrual bleeding and remind the role of a holistic approach to the management of a patient [20].

CONCLUSION

This cross-sectional hospital-based study indicates that iron deficiency anemia is extremely common among women with heavy menstrual bleeding and is directly linked to poor cognitive performance and low physical capacity. The women who had iron deficiency anemia exhibited cognitive ability scores, poorer functional exercise capacity, and muscle forces as compared to the women who had no anemia. These results suggest that the effects of iron deficiency anemia go far beyond the abnormalities related to blood and significantly impact everyday functioning and quality of life. Screening of hemoglobin and iron status is to become part of the regular check-up of women with excessive menstrual bleeding. Early diagnosis and proper treatment of iron deficiency anemia and correction of the cause of bleeding may enhance cognitive efficiency, physical performance, and overall patient outcomes. Further prospective and interventional studies should be done to assess the long-term advantages of integrated managerial strategies to address both heavy menstrual bleeding and iron deficiency anemia.

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Authors' Contributions: K.S. was responsible for study design, data interpretation, and manuscript drafting. A.S. contributed to data collection, clinical assessment, and manuscript revision. S.M.A.A.R. performed data analysis, statistical interpretation, literature review, and critical revision of the manuscript. All authors read and approved the final version of the manuscript.

Data Availability Statement: The data used in this study are available from the corresponding author upon reasonable request, subject to ethical and institutional guidelines.

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