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Iron Deficiency without Anemia and Its Relationship with Fatigue and Concentration Difficulties Among Premenopausal Women

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Abstract

Iron deficiency is a prevalent nutritional problem faced by premenopausal women that can cause problems with both physical and cognitive functioning despite the lack of anemia. Iron deficiency without anemia is defined by low body iron stores, but hemoglobin levels are maintained within normal ranges. In this study, the link between iron deficiency without anemia, fatigue, and concentration difficulties in premenopausal women will be evaluated. The aim of this study is to explore the influence of iron deficiency without anemia on energy levels, concentration, and functioning of women. These complaints are often found in women during their reproductive years and are likely caused by blood loss due to menstruation, low iron intake through diet, and high iron requirements. The use of descriptive and analytical analysis can be helpful in evaluating iron status, fatigue symptoms, and difficulties concentrating in eligible subjects. A statistical correlation between the ferritin level in the serum and the symptoms experienced by participants can be made. The knowledge gained can help improve the recognition of iron deficiency among health care providers to enable timely assessment and evaluation of the condition. The results can further emphasize the significance of the early detection and proper treatment of iron deficiency for increased energy and cognitive abilities of premenopausal women.

Keywords: Iron Deficiency Without Anemia, Premenopausal Women, Fatigue, Concentration Difficulties, Serum Ferritin, Cognitive Function.

1. INTRODUCTION

1.1 Iron Deficiency Without Anemia: An Emerging Women's Health Concern

Iron is a vital micronutrient that plays a critical role in oxygen transport and energy metabolism in the human body. Iron deficiency refers to a situation where there is inadequate iron in the body to meet its physiological needs. Even though iron deficiency leads to anemia in most cases, iron deficiency can occur before one develops anemia. This state is called iron deficiency without anemia, and it is a major health problem among women of reproductive age that is underrecognized. It is important to make a distinction between iron deficiency and iron deficiency anemia since one can have iron deficiency even if he/she has normal hemoglobin levels (Camaschella, 2015).

Symptoms of iron deficiency without anemia include persistent fatigue, low physical fitness, weakness, and difficulty concentrating. All these symptoms can negatively impact one's productivity at

work and daily activities. However, the symptoms of iron deficiency vary widely from person to person, making it hard to recognize this condition. For this reason, it is important to evaluate iron status not only through hemoglobin levels (Beatrix et al., 2022).

1.2 Premenopausal Women and the Hidden Burden of Iron Depletion

Premenopausal women are especially prone to iron deficiency due to frequent blood loss during menstruation, insufficient dietary intake of iron, and higher iron needs. Periodic blood loss occurs during menstrual cycles; thus, heavy and prolonged menstrual flow can increase the probability of developing iron deficiency. Moreover, low intake of iron in food and poor absorption of this mineral, along with specific dietary habits, can predispose women to iron deficiency anemia. Thus, the development of the disease takes place slowly, and signs of the problem become obvious only after they start affecting one's normal life (Cappellini et al., 2022).

The issue of iron deficiency in women cannot be explained only by the biological aspect but is also influenced by various social and healthcare aspects. Different nutritional opportunities, knowledge of the issue, the use of medical care, and the awareness of women's health problems can play a role in delayed diagnosis and treatment of iron deficiency. Women who feel exhausted and have problems with concentrating can consider that the reason is their overload at work or periodical changes. Thus, more attention should be paid to iron deficiency in such women (Tang & Sholzberg, 2024).

1.3 Fatigue and Concentration Difficulties as Functional Health Challenges

Fatigue is one of the symptoms that is often encountered in women who have low levels of iron stores and can appear without hemoglobin concentration falling below the normal range. It can manifest itself in the form of continuous fatigue, lack of energy, exhaustion, or inability to perform regular daily tasks. Iron is involved in energy metabolism processes, so the lack of iron may affect the body's ability to function normally. Thus, in cases where the iron deficiency leads to fatigue in women, it might be related to the lack of the mineral's availability.

Another manifestation of iron deficiency may be the inability to concentrate. It can present in the form of poor attention, inability to focus, lack of memory, or slow processing of information. Such problems may affect performance at school and at work, as well as the overall ability to make decisions. However, these symptoms can also appear together, which means that people may face difficulties in both physical and cognitive functioning. Nevertheless, fatigue and concentration issues are not very specific symptoms, and their development may be related to sleep problems, stress, eating behavior, and other illnesses.

1.4 Research Problem, Research Gap, Aim and Objectives

Deficiency in iron without anemia is a relatively underappreciated health problem among pre-menopausal women. Hemoglobin levels within the normal range may not be an indicator of sufficient iron levels, whereas fatigue and difficulty concentrating can influence daily life and overall

health. But the link between low levels of iron and these consequences still needs to be researched, especially regarding women in the reproductive period. Although some research has been conducted on the link between iron deficiency and the mentioned conditions, not much has been done regarding their concurrent analysis. Thus, the present study intends to research the relationship between iron deficiency without anemia and fatigue and concentration difficulties among premenopausal women.

The research will try to find the prevalence of iron deficiency without anemia, explore the link between ferritin level and fatigue, discover the connection between iron deficiency and difficulties concentrating, and the combined effects of these conditions on the functional ability of women.

2. LITERATURE REVIEW

2.1 Iron Metabolism and the Physiology of Iron Deficiency Without Anemia

Iron is necessary for the production of hemoglobin, oxygen transport, mitochondrial function, and many enzyme reactions. Iron is regulated in the body mainly via the regulation of its absorption in the intestines; recycling of iron takes place due to the disintegration of older red blood cells. Because the body has few ways to excrete iron in excess, iron balance is mainly achieved by controlling the absorption of iron in the intestines. With inadequate intake or absorption of iron to cover for the physiological loss of iron from the body, iron stores are depleted over time. Depletion of iron can take place without the presence of decreased hemoglobin, leading to iron deficiency without anemia (Cappellini et al., 2022). Evaluation of iron status can be achieved by determining biochemical markers, especially serum ferritin, which reflects the body's iron stores.

Thus, the interpretation of iron status may be based on other laboratory parameters such as transferrin saturation and markers of inflammation. Clinical practice guidelines indicate the necessity of proper biochemical evaluation in case of iron deficiency diagnosis and treatment in adults (Snook et al., 2021). Iron deficiency can cause the development of physiological disorders that are not limited to erythropoiesis. The lack of iron can have an impact on cellular metabolism and other physiological processes and thus cause symptoms even if there is no anemia yet. Thus, detection of iron deficiency should include iron stores and symptoms.

2.2 Menstrual Blood Loss and Iron Depletion in Premenopausal Women

Iron losses from menstrual blood are one of the major causes of iron deficiency in premenopausal women. The monthly menstrual cycle leads to monthly iron loss that can be quite significant in cases of excessive or long-lasting menstrual bleeding. Iron deficiencies can be caused by iron insufficiency in food that cannot compensate for these losses. Additional risk factors include restricted diet, low consumption of iron-containing products, and poor iron absorption. Studies of iron deficiency anemia among premenopausal women have included the connection between the condition and metabolism. It was concluded that the problems associated with iron deficiency may include wider physiological effects (Özdemir et al., 2007). It is especially relevant to consider the association of these menstrual

factors and iron status since it is possible for females to suffer from iron deficiency for prolonged periods without suffering from anemia. These individual differences could play a role in the varying serum ferritin levels found in females. Thus, information about these menstrual and nutritional factors could be helpful in evaluating fatigue and lack of concentration among premenopausal females.

2.3 Iron Deficiency and the Biological Mechanisms of Fatigue

Fatigue is among the most commonly researched symptoms associated with iron deficiency not complicated by anemia. Iron plays an important role in mitochondrial processes and energy metabolism; therefore, iron deficiency may affect the ability of the body to conduct physical activity. Despite normal hemoglobin levels, iron deficiency might be responsible for reduced energy, fatigue, and decreased physical endurance. However, fatigue is a polyetiological symptom and can be caused by sleep disorders, psychological stresses, and other nutrient deficiencies. In a systematic review of randomized clinical trials, the influence of iron supplementation on fatigue and physical capacity in adult patients with non-anemic iron deficiency was assessed. It was found that iron supplementation might help to reduce fatigue, but its effect on physical capacity improvement was inconsistent. Thus, fatigue and physical capacity may have different meanings (Houston et al., 2018).

Research involving non-anemic women in their pre-menopause age group and having low ferritin levels has also been conducted in order to analyze the impact of iron administration on fatigue. It has been noted that there are improvements in fatigue due to iron administration, thereby indicating the role of depleted iron stores in causing fatigue without the presence of anemia (Krayenbuehl et al., 2011). Likewise, a randomized controlled study conducted among women who were menstruating and had low ferritin levels along with normal hemoglobin values indicated that there was a decrease in fatigue due to iron administration (Vaucher et al., 2012).

2.4 Iron Depletion and Cognitive Function: Understanding Concentration Difficulties

Iron is very critical in the physiological processes in the brain, such as neurotransmitter production, energy metabolism within the cells, and physiological processes related to attention and learning. Availability of sufficient amounts of iron is critical in ensuring normal physiological processes in the brain. Insufficient storage of iron may affect functions like attention, memory, and the capacity to concentrate even among individuals who do not suffer from anemia. A systematic review that focused on the linkages between iron deficiency, cognition, psychopathology, and fatigue among women of reproductive age established a connection between iron and various functional processes (Greig et al., 2013).

Iron depletion studies conducted on young females have investigated the influence of iron depletion on cognitive performance. It has been found that iron treatment is positively related to the performance of certain cognitive abilities, implying that the state of iron in an organism may have a role in affecting aspects of mental functioning (Murray-Kolb & Beard, 2007). However, there might be differences in the cognitive outcomes depending on the level of iron depletion, type of the cognitive ability measured,

and the particularities of the individuals (Murray-Kolb & Beard, 2007). In addition, studies on iron nutrition in premenopausal women have drawn attention to the consequences of iron depletion for physical and neuropsychological functioning (McClung & Murray-Kolb, 2013). Thus, it could be justified to study the problems with concentration as the relevant functional outcome of iron depletion, rather than focusing only on the effects on fatigue (McClung & Murray-Kolb, 2013). Iron deficiency anemia has also been linked to poor postural control in young females (Harrabi et al., 2021)

3. RESEARCH METHODOLOGY

3.1 Research Design and Study Population

For the study, a descriptive and analytical research approach is employed to investigate the link between iron deficiency without anemia and the association with fatigue and poor concentration among pre-menopausal women. The study will focus on women of childbearing age since there is the possibility of the depletion of iron reserves affecting the physical and psychological function of participants. The study sample will consist of pre-menopausal women within the ages of 18–45 years. Selection of women into the study depends on their eligibility and desire to participate in the study. Women with a medical history of anemia, pregnancy, and other chronic ailments that may have an impact on their iron levels may be excluded from the study. The sociodemographic and menstrual characteristics of participants include their ages, educational level, dietary practices, and menstrual period.

3.2 Assessment of Iron Status Without Anemic Manifestation

Iron status determination will be carried out through biochemical tests, especially serum ferritin, to identify participants with poor iron stores. The level of hemoglobin will be measured at the same time to differentiate between iron deficiency anemia and iron deficiency. The participants who have poor serum ferritin and hemoglobin within the normal reference range will be defined as iron deficiency without anemia according to the set diagnostic criteria. It is noteworthy that serum ferritin is one of the best indicators of iron stores; however, the results of the test may be affected by infections and inflammation. Other factors like transferrin saturation and inflammation may be taken into account when possible.

3.3 Measurement of Fatigue and Concentration Difficulties

Both fatigue and concentration problems are measured through structured surveys or assessment tests. When measuring fatigue, the areas being taken into account include tiredness, low energy, exhaustion, and inability to finish daily tasks. In the case of concentration problems, the measures will involve reduced attention, lack of ability to focus, forgetfulness, and inability to concentrate on everyday tasks. Scoring techniques for the test are standardized when it comes to validated tests. Scores that are higher than average could mean the symptoms have a high severity level, depending on the

assessment test selected. The gathered data is then analyzed to see the connection between iron deficiency and the described symptoms.

3.4 Data Collection, Ethical Considerations, and Statistical Analysis

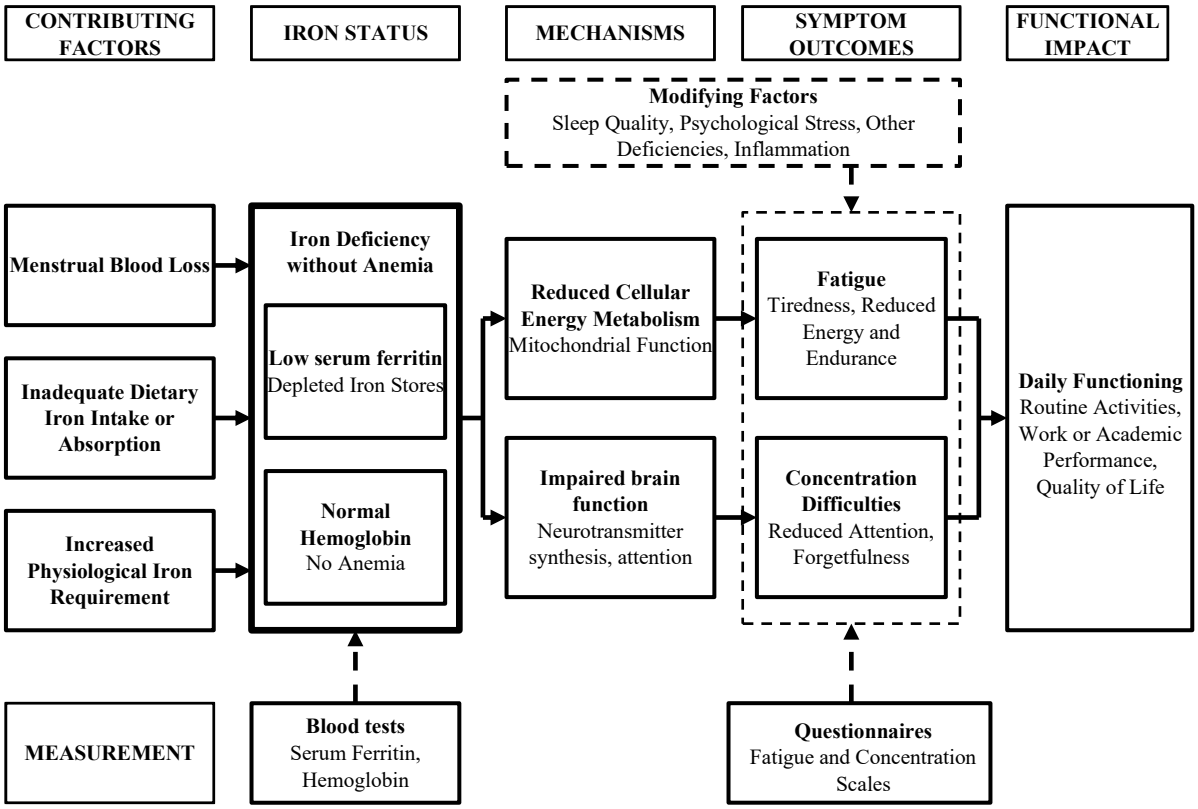


Figure 1: Conceptual Framework Illustrating the Relationship Between Iron Deficiency Without Anemia, Fatigue, and Concentration Difficulties

The data is gathered through participant questionnaires and laboratory measures of serum ferritin and hemoglobin. Participants will be informed about the aims of the study, processes, and that participation is completely voluntary. Consent will be acquired prior to the data collection process, and confidentiality will be ensured through the use of coded participant files. Ethical clearance will be sought from the institutional ethics committee prior to the study. Descriptive and inferential statistics will be used in the analysis of the gathered data. Participant demographics, iron levels, symptoms of fatigue, and concentration problems will be analyzed using frequencies and percentages, means, and standard deviations. The correlation between serum ferritin and the symptoms will be assessed using correlation analysis. Relevant group comparison tests and regression analysis will also be used where applicable to test associations between variables, taking into consideration the necessary variables.

Figure 1 shows how certain risk factors, including menstrual bleeding and lack of iron in the diet, could result in low iron stores even though hemoglobin levels are normal. It demonstrates the impact of this condition on cell energy production and the brain, thus causing fatigue and inability to concentrate.

4. RESULTS AND ANALYSIS

4.1 Sociodemographic Characteristics and Distribution of Iron Deficiency Without Anemia

Sociodemographic and menstrual features of the subjects are investigated in order to determine the prevalence of iron deficiency without anemia among the participants. Age, education level, food habits, menstrual cycle, and menstrual blood flow are some of the factors that have been considered. The prevalence of low serum ferritin and hemoglobin among participants with low iron stores and no anemia is determined. The prevalence of iron deficiency without anemia is then established based on the number of eligible subjects who satisfy the biochemical requirements. The results obtained show the general iron status among the pre-menopausal subjects.

4.2 Patterns of Fatigue and Concentration Difficulties Among Participants

The symptoms of fatigue and concentration difficulty are examined to determine how frequently and how severely such symptoms occur among the pre-menopausal women. In the case of fatigue symptoms, the scores are examined in terms of being tired, lack of energy, and difficulties in carrying out normal tasks. Likewise, concentration difficulties are examined in terms of difficulty in paying attention, maintaining mental effort, and cognition. Distribution of the scores of the symptoms is analyzed to see patterns of the physical and cognitive symptoms. Iron-deficient but non-anemic women and iron-sufficient women are compared with each other in terms of the scores for fatigue and concentration difficulties.

Table 1 provides a comparison of iron status, fatigue, and concentration problems in premenopausal women with iron deficiency without anemia compared to those with normal iron status. It demonstrates that women suffering from iron deficiency may have more symptoms despite having normal hemoglobin levels.

Table 1: Comparison of Iron Status, Fatigue, and Concentration Difficulties Among Premenopausal Women

Variables	Iron Deficiency Without Anemia (n=50)	Normal Iron Status (n=50)
Mean Serum Ferritin (ng/mL)	14.2 ± 5.6	48.5 ± 16.3
Mean Hemoglobin (g/dL)	12.6 ± 0.7	13.1 ± 0.6
Participants Reporting Fatigue (%)	72%	34%
Participants Reporting Concentration Difficulties (%)	64%	28%
Mean Fatigue Score	18.4 ± 4.2	11.2 ± 3.5
Mean Concentration Difficulty Score	15.6 ± 3.8	9.4 ± 2.9

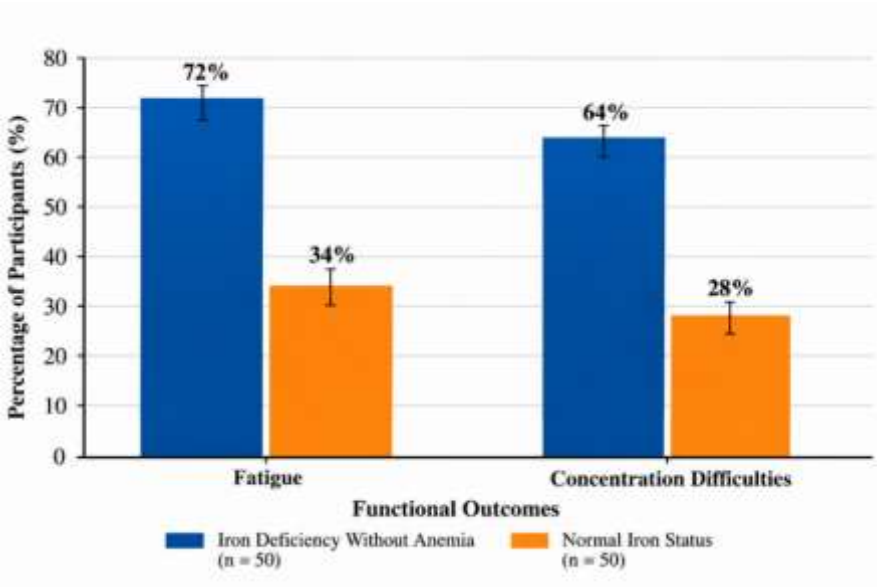


Figure 2: Comparison of Mean Fatigue and Concentration Difficulty Scores Based on Iron Status

Figure 2 demonstrates the disparity in average scores of mean fatigue and difficulty concentrating in women suffering from iron deficiency but without anemia compared to women with normal levels of iron. The higher average score for iron-deficient women implies that they experienced more fatigue and difficulty concentrating.

4.3 Relationship Between Serum Ferritin Levels and Fatigue Severity

The connection between serum ferritin concentrations and fatigue severity is analyzed using proper statistical techniques. Serum ferritin values are correlated with fatigue values in order to determine if lower iron concentrations lead to increased fatigue and decreased energy levels. The correlation analysis will be performed in order to measure the direction and magnitude of the connection between the two variables. If a negative correlation between serum ferritin values and fatigue values is found, it means that the lower concentration of iron in the body leads to increased fatigue. Nevertheless, the results of the analysis will be interpreted with other factors in mind, such as menstrual blood loss, diet, and sleep quality.

4.4 Association Between Iron Deficiency Without Anemia and Combined Functional Outcomes

The relationship between iron deficiency in the absence of anemia and the inability to concentrate is considered together with fatigue in order to understand the joint effects on functioning. Participants with iron deficiency are compared with participants with normal iron levels based on the physical and mental symptoms they experience. Statistical analysis is conducted to determine whether iron deficiency without anemia causes higher fatigue and problems with concentration. In addition to that, the joint effect is assessed by determining whether participants with higher fatigue levels also have problems with concentration. The findings might reveal the patterns of concomitant symptoms experienced by premenopausal women due to iron deficiency.

5. DISCUSSION AND CONCLUSION

5.1 Interpretation of Iron Deficiency Without Anemia and Its Functional Implications

The results obtained from this study help one understand the situation of iron deficiency in the absence of anemia and its possible connection with fatigue and difficulty concentrating on things for premenopausal women. Iron deficiency is indicated by low serum ferritin levels, which might be accompanied by the presence of hemoglobin within normal values. It is evident that the connections that exist between the state of iron and symptoms that people experience help one understand that it is necessary to think about the state of the body in a wider context than just anemia. It is also necessary to consider other factors as well.

5.2 Fatigue, Concentration Difficulties, and Menstrual Characteristics

The issues of fatigue and difficulty with concentration are some examples of functional problems that might influence the quality of life of premenopausal women. The correlation between serum ferritin levels and fatigue can give hints on whether the availability of iron is essential for the body's energy. Also, a connection between iron depletion and difficulties with concentration might suggest that iron deficiency plays a role in cognitive functioning. Menstrual traits, especially the duration and intensity of bleeding, could add more diversity to the differences in the levels of iron and the manifestation of symptoms.

5.3 Clinical Implications, Early Identification, and Recommendations

The research emphasizes the significance of the need to identify cases of iron deficiency not associated with anemia as a possible reason for fatigue and poor concentration in premenopausal women. The evaluation of ferritin levels in addition to hemoglobin might be useful in identifying women with decreased iron stores that would be overlooked by standard screening for anemia. Medical practitioners might take into consideration the need to evaluate iron deficiency in women who complain about fatigue and difficulty concentrating, especially in cases of menstrual bleeding or insufficient intake of iron from food. Nutritional education and proper lab work can help improve women's health.

5.4 Conclusion, Limitations, and Future Research Directions

The purpose of the study is to improve understanding of the relationship between iron deficiency without anemia, fatigue, and problems with concentration in premenopausal women. The results of the investigation will help raise awareness of the problem and understand possible implications of iron deficiency in this population. The results of the study may demonstrate the significance of diagnosing and proper assessment of the iron status in women. The study may be limited due to the sample size, patient selection, subjective data collection, and other factors like sleep patterns, diet, and menstrual peculiarities. In case of using cross-sectional design, no causation can be established. Future studies may involve a wider sample of participants, use longitudinal design, as well as standardized tests for

cognitive functioning and fatigue level. Future research may also assess the effect of iron deficiency treatment on cognitive functioning.

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