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Relation Between Iron Deficiency Anemia and Inflammatory Marker in Female of Assam downtown University: With Reference to Body Weight

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ABSTRACT

This study explores the relationship between iron deficiency anemia, inflammatory markers, and body weight among female students at Assam down town University. Despite high awareness of iron deficiency, only 9% reported using iron supplements, indicating a gap between knowledge and health behavior. Anthropometric and hematological assessments revealed wide variability in BMI, hemoglobin, and iron levels, with evidence of both underweight and obese individuals. Inflammatory markers such as Erythrocyte Sedimentation Rate (ESR) and C-reactive protein (CRP) showed significant associations with higher body weight, suggesting increased inflammation in overweight and obese participants. A positive correlation between age, BMI, and ESR further supports the link between weight and systemic inflammation. These findings underscore the need for targeted interventions focusing on weight management, regular screening, and improved health education to address iron deficiency anemia and its associated inflammatory risks

Keywords: *Iron deficiency anemia, Body mass index (BMI), C-reactive protein (CRP), Erythrocyte Sedimentation Rate (ESR)*

1. INTRODUCTION

Anemia:

Anemia is defined by a decline in hemoglobin concentration (below 13.5g/dl in men and below 12g/dl in women), hematocrit (below 41% in men and below 36% in women), or the quantity of red blood cells per cubic millimeter (ELMoslemany *et al.,* 2019). It is a persistent public health challenge where in the blood's oxygen-carrying capacity is diminished, typically resulting from an insufficient level of hemoglobin (Hb) that fails to meet the body's requirements (Altaf *et al.,*2019) .The hemoglobin thresholds employed for diagnosing anemia differ based on factors such as age, sex, elevation above sea level, smoking habits, and pregnancy status(Garcia Casa *et al.,* 2019).

Anemia constitutes a widespread public health issue, impacting both developing and developed nations, with a global prevalence of 22.8%. This condition has significant repercussions on human health, as well as social and economic development. The area's most heavily affected are Western Sub-Saharan Africa, South Asia, and Central Sub-Saharan Africa (ELMoslemany *et al.*,2019).

Inadequate access to balanced diets and a lack of awareness about healthy eating habits contribute to poor dietary practices, leading to the development of both non-communicable and communicable diseases. Globally, the primary contributing factors are Dietary iron deficiency, Vitamin A deficiency, and Beta-thalassemia trait, respectively (Chaparro *et al.,* 2019)

Iron Deficiency Anemia:

Iron deficiency represents potentially the most prevalent nutritional deficiency globally, posing a substantial public health concern in both developed and developing countries. Worldwide, there were in excess of 1.2 billion cases of Iron Deficiency Anemia (IDA), with prevalence rates ranging from 9-11% in adolescent girls and women of childbearing age to 2-6% in adolescent males nationally (Huang *et al.,*2018).

Iron is a nutritionally crucial trace element vital for optimal physical and cognitive performance. The iron levels in the human body are meticulously regulated and typically maintained at approximately 8-18mg per day in women and about 8-11mg per day in men (NIH; 2021)

Iron deficiency remains the most common micronutrient deficiency globally, leading to iron deficiency anemia characterized by hypochromic, microcytic RBCs. Iron deficiency progresses from iron store depletion to impaired transport and enzyme loss, leading to anemia (McClung *et al.*,2019).

Iron deficiency anemia in adolescent female:

Adolescence is a phase marked by swift growth and development, where nutrition holds a crucial significance. Among adolescent females, iron deficiency anemia is a prevalent issue with substantial implications for personal health. Iron, a micronutrient, plays an essential role in both hemoglobin production and enzyme function (Eftekhari *et al.,* 2019).

Globally, the occurrence of anemia in adolescents stands at 27% in developing nations and 6% in developed ones. In Indonesia, anemia poses a significant health challenge, affecting 22.7% of women of childbearing age, 37.1% of pregnant women, and ranging from 30.0% to 46.6% among female workers (Sari *et al.,* 2022).

Iron deficiency anemia (IDA) is notably prevalent among pregnant women, children under five, adolescent girls, and women, primarily owing to their elevated nutritional demands for iron. Iron, a micronutrient essential for hemoglobin production and enzyme function, plays a crucial role in menstruation, physical growth, reproductive maturation, and cognitive development and activity (Jalambo *et al.,* 2019).

Inflammation:

Inflammation is a complex and essential response to biological, chemical, or physical stimuli. Its cellular and molecular mechanisms remain under study. Initially, immune cells migrate to the injury site, guided by cytokines, chemokines, and acute-phase proteins. (Dignass *et al.,* 2018).

The severity of injury determines if acute inflammation can initiate healing. Prolonged or dysregulated responses may lead to chronic inflammation, causing tissue damage and fibrosis, and are associated with diseases like arthritis, asthma, atherosclerosis, autoimmune disorders, diabetes, cancer, and aging-related conditions. (Germolec *et al.,* 2018).

It is identified by the acute-phase response, marked by increased levels of inflammation indicators like C-reactive protein (CRP, >0.3 mg/dL) and pro-inflammatory cytokines that stimulate the production of CRP. (Ueda *et al.,* 2018)

Effect of obesity and inflammation on iron homeostasis:

Obesity is a risk factor for several comorbidities and complications, including iron deficiency anemia. Obesity can disturb the balance of iron in the body, leading to this type of anemia. The link between obesity and iron deficiency might be attributed to elevated levels of hepcidin and ferritin induced by persistent inflammation (Alshwaiyat *et al.,* 2021).Patients with inflammatory conditions may have diminished iron stores, a situation described as "absolute iron deficiency." As in patients without inflammation, this can arise due to low dietary iron intake, poor iron absorption, and/or blood loss. . In some cases, however, there may be adequate iron stores, with normal levels of serum ferritin, but insufficient iron is delivered by transferrin to meet cells' demand, a situation termed "functional iron deficiency"(Dignass *et al.*, 2018).

Ferritin stores iron, representing iron status while Hepcidin binds to hepcidin, thereby inhibiting iron absorption/efflux. Incase of Inflammation it increases ferritin and hepcidin independent of iron status, which reduce iron availability. Hepcidin is a small peptide hormone that is considered a key regulator for body iron homeostasis. Hepcidin is synthesized mainly in the liver and produced at low levels in other organs like adipose tissue (Ueda *et al.*,2018).Obesity causes chronic inflammation, which is associated with the expression and release of pro-inflammatory cytokines, including interleukin-6 (IL-6) and tumour necrosis factor-a (TNF-a). These pro-inflammatory cytokines may result in the release of hepcidin from the liver or adipose tissue. The potential role of hepcidin in the development of iron deficiency in the obese is supported by the discovery of elevated hepcidin levels in tissue from patients with severe obesity (McClung *et al.,*2019).

Obesity:

Obesity is characterized as a medical condition marked by an excessive accumulation of body fat that has a detrimental impact on one's health. (McClung *et al.,* 2019). In just a few decades, obesity has emerged as a worldwide issue in public health. Over 1 billion individuals globally are affected, comprising 650 million adults, 340 million adolescents, and 39 million children. Regional variations indicate the highest prevalence in the south (46.51%) and the lowest in the east (32.96%) (Chooi *et al.,*2019).As previously mentioned, the South Asian region, encompassing India, is witnessing one of the most rapid increases in obesity rates globally. Approximately 135 million people in India are estimated to be obese. According to the Indian National Family Health Survey-4, over a decade, the prevalence of obesity among women aged 15 to 49 rose from 13% to 21%, while for men in the same age group, it increased from 9.3% to 19% (Venkatrao *et al.,* 2020).

The World Health Organization (WHO) predicts that by 2030, 30% of global deaths will result from lifestyle diseases. These fatalities can be averted through the proper identification of related risk factors and the implementation of behavioural intervention plans. Emphasizing health behaviour change is crucial to mitigate the risk of life-threatening consequences (Chatterjee *et al.,* 2020).

Excess weight and obesity stand out as primary risk factors for numerous chronic diseases, including cardiovascular diseases, diabetes (specifically diabetes mellitus), various forms of cancer, a range of musculoskeletal disorders, and mental health issues. Additionally, it's noteworthy that iron deficiency or hypoferremia is the most widespread single micronutrient deficiency on a global scale (Alshwaiyat *et al.,* 2021).Obesity can manifest at any stage of life, and its occurrence has risen among individuals of all ages, without discrimination based on geographical location, ethnicity, or socioeconomic status (Chooi *et* al., 2019).

Body mass index (BMI):

The body mass index (BMI) serves as a dependable indicator of the health and nutritional status of individuals. Commonly interpreted as a measure of an individual's fatness, it is extensively employed as a risk factor assessment for various health conditions The World Health Organization has established BMI-based categories classifying individuals as underweight, normal weight, overweight, or obese (ELMoslemany *et* al., 2019).

The body mass index (BMI) is calculated by dividing an individual's weight in kilograms by the square of their height in meters. This uncomplicated metric is a widely used indicator of overall body fatness. In epidemiological studies, BMI is frequently employed to categorize individuals as overweight or obese. However, it is important to note that BMI exhibits low sensitivity, and there is significant variability in percent body fat among individuals with the same BMI, influenced by factors like age, gender, lack of physical activity, unhealthy eating behaviours, not getting enough good-quality sleep, high amounts of stress, genetics and ethnicity (Chooi *et* al., 2019)

2. MATERIALS AND METHODS

Study population:

A prospective study was conducted in the Department of Medical laboratory technology of Assam downtown University, Guwahati, Assam. Ethical clearance for this study was obtained from the ethical clearance committee of Assam downtown University (Memo No.: AdtU/Ethics/stdnt-lett/2024/154).

Study Subjects A total of number of 100 cases was studied among the females above 18 years of age. Females on menstruation and below 18 years in Assam downtown University were excluded from the study. A questionnaire was used to collect the data and information about the subjects, which includes name, gender, educational qualification, life style, age, weight, etc.

Statistical measurements were applied SPSS software as per requirement of the analysis of the data.

Inclusion criteria: Females in Assam downtown university above 18 years of age.

Exclusion criteria: Females on menstruation and below 18 years of age.

Method of Sample Collection: 7ml of blood is collected intravenously in EDTA, sodium citrate 3.8% and plain vial for different test.

- Hemoglobin estimation (Cyanmethemoglobin Method).
- Red blood cell count (Hemocytometer).
- Packed cell volume (Wintrobe method).
- Erythrocyte sedimentation rate (Westergren method).
- Total iron binding capacity (Ferrozine/ MgCO3 method).
- C-reactive protein. (RELAX-CRP Slide method)

3. RESULT

Table1. Socio-demographic and physiological characteristics of subjects (n = 100).

Socio-demographic characteristics	Percentage distribution
Family type	
Nuclear	84%
Joint	16%
Diet habits	
Vegetarian	6%
Non-vegetarian	94%
Bleeding disorder	
Present	5%
Absent	95%
Chronic illness	
Present	2%
Absent	98%
Inflammatory disease	
Present	0%
Absent	100%
Menstrual cycle	
Regular	80%
Irregular	20%
Marital status	
Married	55%
Unmarried	45%
Do you have any knowledge about iron deficiency	
Yes	85%
No	15%
Iron supplement:	
Yes	9%
No	91%

Table1.Shows the percentage distribution of socio-demographic and physiological characteristics of participants.According to the result majority of the subjects hailed from nuclear families, constituting 84% of the participant , while the remaining 16% belonged to joint families. Regarding dietary habits, a significant 94% of participants reported a preference for non-vegetarian, with the remaining 6% adhering to a vegetarian diet. Notably, 5% of the subjects disclosed the presence of a bleeding disorder, whereas the vast majority, comprising 95%, did not report such conditions. Similarly, chronic illnesses

were reported by a mere 2% of participants, leaving 98% unaffected by long-term health issues. Inflammatory diseases were entirely absent among the subjects, with 100% reporting no such conditions. Concerning menstrual health, 80% of participants reported regular cycles, while 20% experienced irregularities in their menstruation patterns. Marital status exhibited a relatively balanced distribution, with 55% of subjects being married and 45% unmarried. In terms of health awareness, a noteworthy 85% of participants claimed familiarity with iron deficiency, leaving only 15% uninformed on the subject. However, despite the high awareness, only 9% of participants reported taking iron supplements, indicating a potential gap between knowledge and action within the cohort.

Table 2: Determination of mean values (±SD) of anthropometric and physiological parameters (n = 100)

Anthropometric and Physiological Parameters	Minimum value	Maximum value	Mean ± SD
Age (year)	18	40	24.97 ±4.75
BMI	15.60	41.60	23.06±4.90
HB% (g/dl)	6.7	14.10	11.58±1.30
Iron(µg/dl)	55.0	200	110.33±22.08
TIBC(µg/dl)	154.0	380	251.85±62.47
ESR(mm/hr)	3.0	85	18.91±13.31
PCV%	22.40	42.30	35.71±3.54
RBC (million/cumm)	2.79	5.75	4.29±4.26

Table no 2. Shows the minimum and maximum value of anthropometric and physiological parameters and also shows the mean value of all the different parameters. The age ranges from 18 to 40 years, with a mean age of 24.97 ± 4.75 years. Body Mass Index (BMI) exhibited considerable variability, ranging from 15.60 to 41.60, with a mean ± SD of 23.06 ± 4.90. Hemoglobin (HB) levels ranged from 6.7% to 14.10%, with a mean ± SD of 11.58 ± 1.30, indicating a moderate variation across the sample. Iron levels displayed a wide range, from 55 mg/dl to 200 mg/dl, with a mean ± SD of 110.33 ± 22.08, suggesting significant diversity in iron status among the subjects. Total Iron-Binding Capacity (TIBC) ranged from 154 mg/dl to 380 mg/dl, with a mean ± SD of 251.85 ± 62.47, reflecting variability in the body's capacity to bind iron. Erythrocyte Sedimentation Rate (ESR) ranged from 3 mm/hr to 85 mm/hr, with a mean ± SD of 18.91 ± 13.31, indicating varying degrees of inflammation or tissue injury. Packed Cell Volume (PCV) ranged from 22.40 to 42.30, with a mean ± SD of 35.71 ± 3.54, Red Blood Cell (RBC) count ranged from 2.79 to 5.75 million/cumm, with a mean ± SD of 4.29 ± 4.26.

Table 3. Comparison of haematological parameters according to body weight category of study subjects (n = 100).

Haematological parameters	Body weight categories (according to BMI values)				P VALUE
	Underweight (n=15)	Normal body weight (n-53)	Overweight (n-21)	Obese (n-11)	
HB %(g/dl)	11.96±1.12	11.41±1.41	11.61±1.13	11.82±1.30	0.46 ^{ns}
Iron(µg/dl)	110.40±145.90	110.13±24.68	107.43±22.15	116.73±17.84	0.74 ^{ns}

TIBC(µg/dl)	**244.93±62.43**	**242.04±61.88**	**262.95±55.32**	**287.45±70.08**	**0.12 ^{ns}**
ESR(mm/hr)	**13.0±5.39**	**17.62±12.11**	**22.95±17.11**	**25.45±14.90**	**0.04***
PCV%	**36.91±3.18**	**35.26±3.71**	**35.96±3.42**	**35.98±3.36**	**0.43 ^{ns}**
RBC(million/cumm)	**4.37±0.53**	**4.27±0.47**	**4.24±0.40**	**4.38±0.42**	**0.76 ^{ns}**

Data are expressed as mean±SD; * represents p value <0.05; ns = non significant (p>0.05).

In table no 3.Comparison of haematological parameters according to body weight category of study subjects are done which shows, a significant mean value difference in ESR. The mean value of ESR was slightly decreased among the females with the significance difference of 0.04. Whereas other haematological parameters (HB%, IRON, TIBC, PCV% and RBC) were not statistically significant.

Table 4 : Percentage of CRP reactivity among the study groups.

Body weight category	**CRP reactivity (%)**	
	CRP REACTIVE	**CRP NON REACTIVE**
UNDERWEIGHT (n=15)	**0 (0%)**	**15 (100%)**
NORMAL (n =53)	**1 (1.89%)**	**52 (98.11%)**
OVERWEIGHT (n =21)	**2 (9.5%)**	**19 (90.5%)**
OBESE (n = 11)	**3 (27.27%)**	**8 (72.73%)**

Table no 4. Shows that in underweight category 100% showed a non-reactive CRP status. In the normal weight group 98.11%,exhibited a non-reactive CRP status, while a minor portion, 1.89%, demonstrated CRP reactivity. In the overweight category, only 9.5% of participants displayed CRP reactivity, with the remaining 90.5% showing a non-reactive CRP status. Interestingly, the obese group displayed the highest proportion of CRP reactivity, with 27.27% of participants showing CRP reactivity and 72.73% displaying a non-reactive CRP status. These findings underscore an association between CRP reactivity and higher BMI categories, suggesting a potential link between obesity and inflammatory processes.

The results have been depicted through graphical representation.

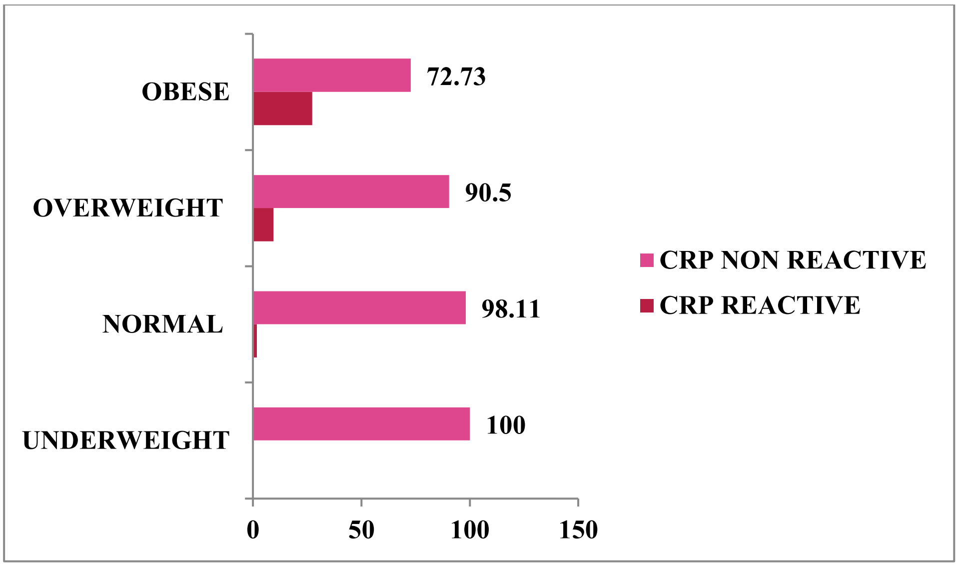
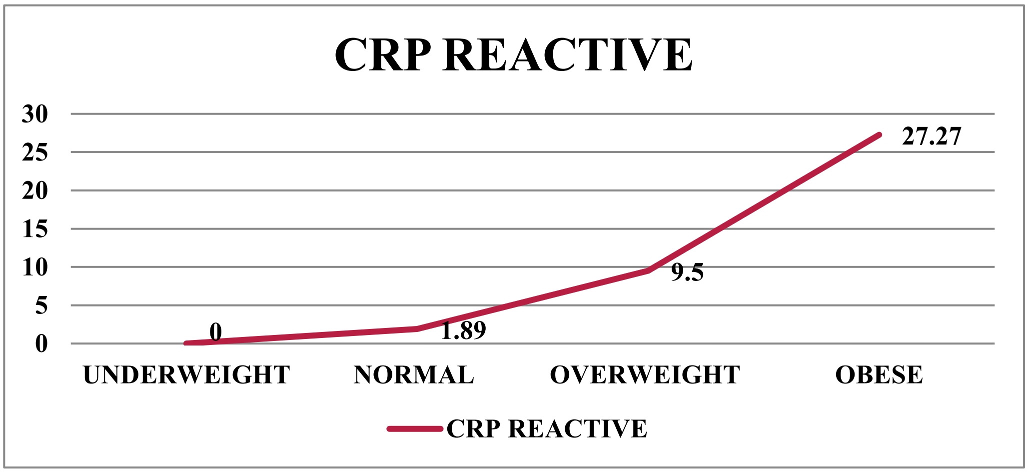


Figure 1: Percentage distribution of CRP reactivity according to body weight categories of subjects.

Figure number 1 is a Percentage distribution of CRP reactivity according to body weight categories of subjects which shows that as body weight increases, there's a corresponding decrease in the percentage of CRP non-reactive individuals. The highest percentage of CRP non-reactive individuals is observed among the underweight category (100%), followed by normal weight (98.11%), overweight (90.5%), and obese individuals (72.71%). This indicates a potential association between higher body weight and increased inflammation, as reflected by CRP reactivity.



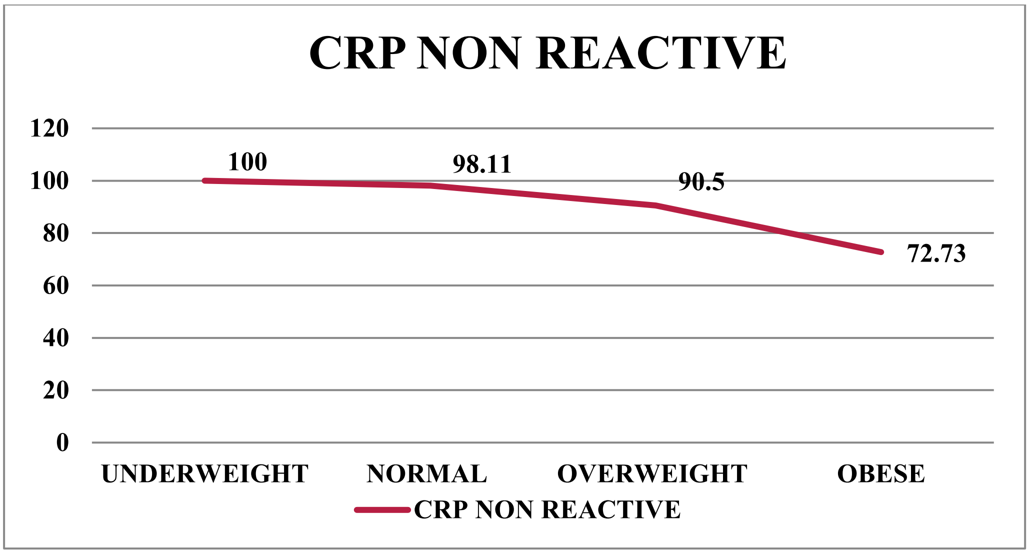


Figure 2. Trends line of percentage changes of CRP reactive subjects and non reactivewith the changes of body weight.

Figure 2.Underscore the potential association between higher body weight and increased inflammation, as reflected by CRP reactivity. This comparison reveals a clear relationship between CRP reactivity and body weight were CRP reactivity increases steadily with higher body weight categories and CRP non-reactivity decreases as body weight decreases.

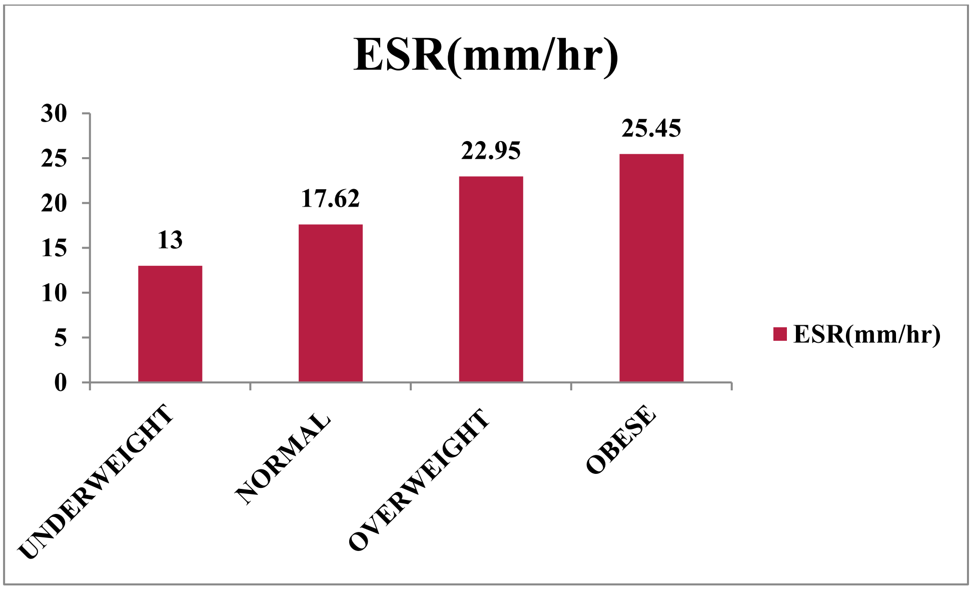


Figure 3. Mean ESR changes with the changes of body weight.

Figure 3. indicates an increase in mean ESR with higher body weight categories. Underweight individuals have the lowest mean ESR at 13 mm/hr, normal weight individuals show a slight increase in mean ESR to 17.62 mm/hr, Overweight individuals exhibit a further increase to 22.95 mm/hr and Obese individuals have the highest mean ESR at 25.45 mm/hr. This suggests a potential association between higher body weight and increased inflammation, as indicated by the ESR levels.

Table 5. Correlation between anthropometric variable, hematological parameters and inflammatory markers.

Anthropometric and haematological	Inflammatory markers	
	ESR(mm/hr)	CRP

parameters	**r**	**P**	**r**	**P**
Age(years)	**0.24**	**0.01***	**0.10**	**0.29ns**
BMI	**0.32**	**0.001****	**-0.03**	**0.764ns**
HB %(g/dl)	**-0.24**	**0.01***	**0.09**	**0.344ns**
RBC(million/cumm)	**-0.36**	**0.00****	**0.06**	**0.51ns**
Iron(µg/dl)	**-0.17**	**0.84 ns**	**-0.01**	**0.92ns**
TIBC(µg/dl)	**-0.004**	**0.97 ns**	**0.04**	**0.64ns**
PCV%	**-0.26**	**0.008****	**0.13**	**0.19ns**

Pearson's correlation table**; * denotes p<0.05, ** denotes p<0.001; ns denotes p>0.05**

Table no 5. Shows the Correlation between anthropometric variable, haematological parameters and inflammatory markers.The results indicate a significant positive correlation between age and BMI with ESR (erythrocyte sedimentation rate). In contrast, other parameters exhibit a significant negative correlation with ESR, except for iron and TIBC (total iron-binding capacity), which show a non-significant correlation. Regarding CRP (C-reactive protein), all parameters show a non-significant correlation. Specifically, BMI and iron have a non-significant negative correlation with CRP, while the other parameters demonstrate a non-significant positive correlation with CRP.

4. DISCUSSION

The study investigates the relationship between iron deficiency anemia, inflammatory markers, and body weight among females at Assam down town University. The socio-demographic data indicates a predominant nuclear family structure and a strong preference for non-vegetarian diets among the participants. Despite high awareness of iron deficiency, the low uptake of iron supplements (9%) suggests a gap between knowledge and proactive health management.

Anthropometric and physiological parameters reveal considerable variability in BMI, hemoglobin levels, and iron status. The mean BMI of 23.06 ± 4.90 suggests a generally healthy weight range, but the wide range indicates the presence of both underweight and obese individuals in the sample. The hemoglobin levels indicate that some participants might be anemic, given the lower range of 6.7%, while the iron levels vary significantly, highlighting diverse iron statuses among the participants.

The data on Total Iron-Binding Capacity (TIBC) and Erythrocyte Sedimentation Rate (ESR) further suggest varied iron metabolism and inflammatory responses within the group. The significant variation in ESR, which ranges from 3 mm/hr to 85 mm/hr, indicates differing levels of inflammation or tissue injury among the participants.

The comparison of haematological parameters according to body weight categories reveals a significant association between ESR and body weight, with higher body weight correlating with increased ESR levels. This suggests that individuals with higher body weight might experience higher levels of inflammation.

CRP reactivity analysis also shows a clear trend where increased body weight corresponds with higher CRP reactivity, indicating higher inflammation levels among overweight and obese individuals. The findings from Figures 1 and 2 support this, showing a steady increase in CRP reactivity with higher body weight categories. Similarly, Figure 3 indicates an increase in mean ESR with higher body weight, reinforcing the association between increased body weight and inflammation.

Table 5 highlights a significant positive correlation between age and BMI with ESR, suggesting that older and heavier individuals are more likely to have higher inflammation levels. In contrast, other parameters exhibit a significant negative correlation with ESR, except for iron and TIBC, which show non-significant correlations. Interestingly, none of the parameters show a significant correlation with CRP, although BMI and iron exhibit a non-significant negative correlation with CRP, while other parameters show a non-significant positive correlation.

5. CONCLUSION

This study highlights a significant relationship between iron deficiency anemia, inflammatory markers, and body weight among females at Assam down town University. Higher BMI is associated with increased levels of inflammatory markers such as ESR and CRP, indicating a potential risk of inflammation-related health issues in overweight and obese individuals. The findings underscore the importance of managing body weight to reduce inflammation and associated health risks.

Despite high awareness of iron deficiency, the low rate of iron supplement usage points to a need for better health education and intervention programs to bridge the gap between knowledge and action. Additionally, the wide variability in iron status and hemoglobin levels suggests that regular screening and targeted interventions are necessary to address iron deficiency anemia effectively. Overall, the study provides valuable insights into the interplay between body weight, iron deficiency anemia, and inflammatory markers, emphasizing the need for holistic health management strategies that include dietary improvements, weight management, and regular health monitoring.

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CONFLICT OF INTEREST

The authors declare that there have no conflict of interest.

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