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Association Between The Presence Of Iron Deficiency Anaemia And HbA1c Levels in Non-Diabetic Individuals

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Abstract:

Background:*HbA1c is widely used as a screening test for diabetes mellitus, In addition, HbA1c ≥6.5% (48mmol/mol) is recommended as the cutoff point for diagnosing diabetes mellitus (DM). This study aimed to find out the effect of iron deficiency anaemia on HbA1c levels in non-diabetic individuals.****Methods:****A case control study was conducted in outpatient Clinic of Internal Medicine Department in Zagazig University Hospitals from the period of February 2019 to September 2019. Included 90 cases, the subjects have been divided into 3 groups; Group1: Include 30 persons who are healthy. Group2: Include 30 persons who have iron deficiency anaemia. Group3: Include 30 persons who have any type of anaemia other than iron deficiency anaemia. Detailed history of clinical examination and biochemical examination was performed including HbA1c****. Results:*** *The study revealed that there was high significant difference between the before and after treatment in iron deficiency group as regard HbA1c and there was no significant difference between the studied groups as regard FBG or PPG*. ***Conclusion:*** *There is significant relation between HbA1c and iron deficiency anemia while there is no relation between iron deficiency anemia and Fasting blood sugar or Post prandial sugar, Iron deficiency anemia elevates HbA1c levels in non-diabetic individuals.*

Keywords: *Iron deficiency anemia, HbA1c, Non diabetic.*

I. INTRODUCTION

Hemoglobin A1c (HbA1c) is a glycated hemoglobin that can be used as an indicator of a patient's glycemic status over the previous 3 months[1].HbA1c is the predominant hemoglobin found in HbA1 fractions. According to the American Diabetes Association Guidelines published in 2007, HbA1c levels should be maintained below 7% in all diabetic patients in order to prevent the development of microvascularcomplications[2].

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Iron deficiency is the state in which the iron content of the body is less than normal. The earliest stage of iron deficiency is depletion of iron stores, in which the serum iron, transferrin saturation and hemoglobin levels will be normal but the storage iron is decreased or absent. Further advanced stage is iron deficiency without anemia, characterized by depleted iron stores, low serum iron and transferrin saturation but without anemia[3].

Iron deficiency anemia is the far most advanced stage of iron deficiency. It is characterized by absent iron stores, low serum iron levels, low transferrin saturation with low hemoglobin levels[4].

Iron deficiency anemia is most prevalent in women and children in regions where meat intake is low, food is not fortified with iron, malaria, intestinal infections and parasitic worms are common[5].Because of the important role of HbA1c on DM diagnosis and the high prevalence of anaemia worldwide, the aim of this study was to investigate the effect of IDA on HbA1c levels in patients without DM.

II. Patients and methods:

After approval was taken from the ethical clearance committee and verbal consent was taken from all the patients, a case control study was carried out in outpatient Clinic of Internal Medicine Department in Zagazig University Hospitals. included90 cases, The patients were randomly divided (by alternation) into three groups 30 patients, Group1: who are healthy mean ± SD of HbA1c in non anaemic patients was5.3± 0.4. Group2: who have iron deficiency anaemia, mean±SD of HbA1c in anaemic patients was 5.6 ± 0.4. Group3: who have any type of anaemia other than iron deficiency anaemia.Inclusion criteria were**:** Patients without anaemia, haemoglobin (Hb) more than 13g/dl (if male) or more than 12g/dl (if female) with serum ferritin above 15 μg/mL and below 150 μg/mL (if female) or below 200 μg/mL (if male),plus complete blood count within the reference values. Patients with IDA- serum ferritin below 15μg/mL,haemoglobin (Hb) below 13g/dl (if male) or below 12g/dl (if female) and mean corpuscular volume (MCV) below 80 fl. Patients with any type o anaemia other than iron deficiency anaemia with,haemoglobin (Hb) below 13g/dl (if male) or below 12g/dl (if female) and mean corpuscular volume (MCV) more than 80 fl.

Quantifying patients were undergoing detailed history, thorough clinical examination and the laboratory investigations were done in the Medical Biochemistry Department and the Clinical Pathology Department of Zagazig University Hospitals and they include; Complete blood picture (CBC). Liver function tests: serum bilirubin (total and direct), serum albumin, serum alanine transaminase and aspartate transferase. Renal function tests: serum creatinine& serum urea. Bleeding profile (Prothrombin time (PT), INR and Partial thromboplastin time (PTT)).

Erythrocyte sedimentation rate (ESR):

The basic principle of the ESR is that when anticoagulated blood is placed in a vertical column the RBCs normally settle quite slowly. This occurs for 2 main reasons: RBCs repel each other due to the negative charges on their surfaces, or zeta potential, and the large surface-area-to-volume ratio of normal RBCs resists settling. The aggregation of RBCs into rouleaux, which happens slowly under normal conditions, markedly accelerates

sedimentation by decreasing the surface-area-to-volume ratio. Conditions that promote the formation of rouleaux produce an elevated ESR. The most common promoter of rouleaux is increased plasma fibrinogen. Fibrinogen's positive charge decreases the RBCs' zeta potential, leading to increased rouleaux and an increased ESR. In fact, the clinical utility of the ESR is largely attributable to increased fibrinogen in acute-phase reactions and chronic inflammatory conditions. The ESR may be elevated by other conditions that decrease the zeta potential or the RBC surface-area-to volume ratio. The zeta potential is reduced by other plasma proteins, including immunoglobulins, as well as cholesterol, phospholipids, and some medications. By creating more space between RBCs, anemia reduces the effect of the zeta potential to slow sedimentation. Decreases in the surface-area-to-volume ratio, as in macrocytosis, also increase the ESR. The ESR may be decreased by conditions that interfere with the formation of rouleaux or increase the RBC surface-area-to-volume ratio. Rouleaux formation is hindered by spherocytosis, sickle cell disease, microcytosis, marked variation in RBC size (anisocytosis), and some drugs. Polycythemia decreases the compactness of rouleaux formation. The surface-area-to-volume ratio is increased in some thalassemias and hemoglobinopathies.

Hemoglobin A1c (HBA1c):

Glycation of proteins is a frequent occurrence, but in the case of hemoglobin, a non-enzymatic reaction occurs between glucose and the N-end of the beta chain. This forms a Schiff base which is itself converted to 1-deoxyfructose. This rearrangement is an example of an Amadori rearrangement. When blood glucose levels are high, glucose molecules attach to the hemoglobin in red blood cells. The longer hyperglycemia occurs in blood, the more glucose binds to hemoglobin in the red blood cells and the higher the glycated hemoglobin. Once a hemoglobin molecule is glycated, it remains that way. A buildup of glycated hemoglobin within the red cell, therefore, reflects the average level of glucose to which the cell has been exposed during its life-cycle. Measuring glycated hemoglobin assesses the effectiveness of therapy by monitoring long-term serum glucose regulation. A1c is a weighted average of blood glucose levels during the life of the red blood cells (117 days for men and 106 days in women). Therefore, glucose levels on days nearer to the test contribute substantially more to the level of A1c than the levels in days further from the test (NGSP: HbA1c and eAG, 2015).

III. Result:

This study showed that there is no significant difference between the studied groups as regard age, sex BMI or Waiste hip ratio **table (1)**.

This study showed that mild anemia was present in 8.3% of cases, moderate in 66.7% of cases and severe anemia in 25% of cases **table (2)**.

There was no significant relation between disease severity and HbAIc**table (3)**.

There was high significant difference between the studied groups as regard hemoglobin, Hematocrite value, Serum iron, HbA1c, Mean Fe level and MCV **table (4)**.

There was high significant difference between before and after treatment in iron deficiency anemia group as regard Hemoglobin, HbA1c, TIBC, Serum ferritin and hematocrite value, while there is no significant difference between before and after treatment in iron deficiency anemia group as regard FBG or PPG **table (5)**.

There was high significant difference between the studied groups as regard hemoglobin, Hematocrite value and MCV **table (6)**.

There was high significant difference between the studied groups as regard reticulocyte count and ferritin. There was no significant difference between the studied groups as regard FBG while, there was high significant difference between the studied groups as regard HbA1c **table (7)**.

There was high significant difference between the before and after treatment in iron deficiency group as regard HbA1c **table (8)**.

There was high significant difference between the studied groups as regard HbA1c after treatment **table (9)**.

There was high significant difference between the studied groups as regard serum iron, TIBC and Transferrin saturation **table (10)**.

Table (1):Comparison between the three studied groups according to demographic data

	Group I (n = 30)		**Group II (n = 30)**		**Group III (n = 30)**		**Test of sig.**	**p**
	No.	**%**	**No.**	**%**	**No.**	**%**		
Sex								
Male	15	50.0	15	50.0	17	56.7	χ^2= 0.356	0.837
Female	15	50.0	15	50.0	13	43.3		
Age (years)								
Min. – Max.	35.0 – 62.0		34.0 – 61.0		35.0 – 62.0		F= 0.814	0.446
Mean ± SD.	48.20 ± 8.58		47.0 ± 7.77		49.77 ± 8.88			
Median (IQR)	50.0 (41.0 – 55.0)		47.0 (42.0 – 52.0)		52.0 (43.0 – 57.0)			
BMI								

Min. – Max.	18-28	18-29	20-30	F=1.02	0.612
Mean ± SD.	22.6±3.31	22.5±3.42	22.7±3.66		
Waiste hip ratio					
Min. – Max.	0.82-0.89	0.81-0.89	0.83-0.89	F= 1.12	0.132
Mean ± SD.	0.87±0.1	0.85±0.11	0.86±0.12		

χ^2: **Chi square test** **F**: **F for ANOVA test**

p: p value for comparing between the studied groups

Table (2):Distribution of anemia cases as regard severity:

	(n = 60)	
	No.	**%**
Severity		
Mild	5	8.3
Moderate	40	66.7
Severe	15	25.0

Table (3):Relation between disease severity and HbAIc:

	Mild (n = 5)	**Moderate (n = 30)**	**Severe (n = 15)**	**Test of sig.**	**p**
HbAIc:					
Min. – Max.	5.0-6.0	5.1-6.2	5.3-6.3	F= 0.931	0.911
Mean ± SD.	5.5 ± 0.4	5.6 ± 0.41	5.7 ± 0.3		

Table (4):Comparison between the three studied groups according to iron profile:

	Group I (n = 30)	Group II (n = 30)	Group III (n = 30)	Test of sig.	p
Hb		**(Before)**			
Min. – Max.	12.30 – 16.90	8.10 – 12.30	9.50 – 13.40	F= 107.091*	<0.001*
Mean ± SD.	14.69 ± 1.33	10.41 ± 1.11	11.22 ± 1.16		
Median (IQR)	14.85 (13.70 – 15.50)	10.25 (9.60 – 11.40)	11.15 (10.10 – 12.10)		
Sig. bet. grps. LSD	$p_1<0.001^*, p_2<0.001^*, p_3=0.029^*$				
HT. (%)		**(Before)**			
Min. – Max.	38.0 – 52.0	31.0 – 45.0	31.0 – 45.0	F= 40.606*	<0.001*
Mean ± SD.	45.40 ± 4.45	36.23 ± 4.45	36.67 ± 4.44		
Median (IQR)	45.0 (43.0 – 49.0)	35.0 (32.0 – 40.0)	36.5 (33.0 – 40.0)		
Sig. bet. grps. LSD	$p_1<0.001^*, p_2<0.001^*, p_3=0.925$				
Mean Fe level (g/dl)					
Min. – Max.	201-276	29.3-60	143.1-203.7	41.205*	<0.001*
Mean ± SD.	234.32±23.4	41.12±10.3	184.32±22.1		
Median (IQR)	235.6(220.2-260.3)	42.3(35.6-54.2)	180.3(162.1-194.2)		
Sig. bet. grps. LSD	$p_1<0.001^*, p_2=0.031^*, p_3<0.001^*$				
Serum iron (microgram)					

Min. – Max.	57.0 – 176.0	12.0 – 47.0	12.0 – 167.0	39.455*	<0.001*
Mean ± SD.	108.8 ± 35.23	29.17 ± 10.73	81.57 ± 48.77		
Median (IQR)	102.5 (80.0 – 147.0)	28.0 (20.0 – 37.0)	80.50 (36.0 – 117.0)		
Sig. bet. grps.	p_1<0.001*,p_2=0.010*,p_3<0.001*				
HbA1c		**Before**			
Min. – Max.	3.90 – 5.40	5.50 – 6.20	4.0 – 5.40	81.230*	<0.001*
Mean ± SD.	4.58 ± 0.51	5.90 ± 0.19	4.72 ± 0.53		
Median (IQR)	4.40 (4.10 – 5.10)	5.90 (5.70 – 6.10)	4.80 (4.20 – 5.30)		
Sig. bet. grps.	p_1<0.001*,p_2=0.456,p_3<0.001*				
MCV		**(Before)**			
Min. – Max.	80.0 – 96.0	65.0 – 79.0	73.0 – 105.0	H= 54.326*	<0.001*
Mean ± SD.	88.0 ± 5.43	75.63 ± 3.57	82.23 ± 7.72		
Median (IQR)	89.0 (83.0 – 93.0)	77.0 (75.0 – 78.0)	80.50 (78.0 – 82.0)		
Sig. bet. grps. LSD	p_1<0.001*,p_2=0.001*,p_3<0.001*				

F: F for ANOVA test, Pairwise comparison bet. each 2 groups was done using Post Hoc Test (Tukey)

H: H for Kruskal Wallis test, Pairwise comparison bet. each 2 groups was done using Post Hoc Test (Dunn's for multiple comparisons test)

p: p value for comparing between the studied groups

p_1: p value for comparing between **normal individuals** and **iron deficiency anemia**

p_2: p value for comparing between **normal individuals** and **other type of anemia**

p_3: p value for comparing between **iron deficiency anemia** and **other type of anemia**

Table (5):Comparison between the two periods according to CBC in iron deficiency anemia group (n = 30)

	Before (n = 30)	**After (n = 30)**	**t**	**p**
Hb				
Min. – Max.	8.10 – 12.30	12.10 – 16.90	11.938*	<0.001*
Mean ± SD.	10.41 ± 1.11	14.09 ± 1.33		
Median (IQR)	10.25 (9.60 – 11.40)	14.05 (12.90 – 14.80)		
HbA1c				
Min. – Max.	5.50 – 6.20	4.90 – 5.60	18.311*	<0.001*
Mean ± SD.	5.90 ± 0.19	5.33 ± 0.18		
Median (IQR)	5.90 (5.70 – 6.10)	5.35 (5.20 – 5.50)		
HT. (%)				
Min. – Max.	31.0 – 45.0	43.0 – 52.0	11.162*	<0.001*
Mean ± SD.	36.23 ± 4.45	47.73 ± 2.82		
Median (IQR)	35.0 (32.0 – 40.0)	47.0 (46.0 – 50.0)		
TIBC				
Min. – Max.	461.0 – 600.0	349.0 – 540.0	17.5	**<0.001 (HS)**
Mean ± SD.	534.1 ± 47.23	394.3 ± 39.61		
Median (IQR)	529.5 (496.0 – 586.0)	399.1 (399.0 – 510.0)		
Serum ferritin				
Min. – Max.	4.0 – 45.0	201-304	26.9	**<0.001**

Mean ± SD.	26.17 ± 14.36	270.4±23.6		**(HS)**
Median (IQR)	29.0 (11.0 – 39.0)	277(220.0 -290.0)		
FBG				
Min. – Max.	70.0 – 97.0	70.0 – 96.0	0.932	0.812
Mean ± SD.	83.40 ± 8.20	82.90 ± 8.40		
Median (IQR)	82.0 (76.0 – 90.0)	81.0 (75.0 – 89.0)		
PPG				
Min. – Max.	111.0 – 133.0	111.0 – 130.0	1.02	0.712
Mean ± SD.	122.3 ± 7.59	121.9 ± 6.9		
Median (IQR)	122.0 (115.0 – 130.0)	121.0 (114.0 – 128.0)		

t: Paired t-test

p: p value for comparing between **before** and **after**

*: Statistically significant at $p \leq 0.05$

Table (6):Comparison between the three studied groups according to CBC

	Group I(n = 30)	**Group II(n = 30)**	**Group III(n = 30)**	**F**	**p**
Hb		**(After)**			
Min. – Max.	12.30 – 16.90	12.10 – 16.90	9.50 – 13.40	63.684	<0.001*
Mean ± SD.	14.69 ± 1.33	14.09 ± 1.33	11.22 ± 1.16		
Median (IQR)	14.85 (13.70 – 15.50)	14.05 (12.90 – 14.80)	11.15 (10.10 – 12.10)		
Sig. bet. grps.LSD	p_1=0.164,p_2<0.001*,p_3<0.001*				
HT. (%)		**(After)**			
Min. – Max.	38.0 – 52.0	43.0 – 52.0	31.0 – 45.0	64.657*	<0.001*

Mean ± SD.	45.40 ± 4.45	47.73 ± 2.82	36.67 ± 4.44		
Median (IQR)	45.0 (43.0 – 49.0)	47.0 (46.0 – 50.0)	36.5 (33.0 – 40.0)		
Sig. bet. grps.LSD	p_1=0.065,p_2<0.001*,p_3<0.001*				

F: F for ANOVA test, Pairwise comparison bet. each 2 groups was done using Post Hoc Test (Tukey)

H: H for Kruskal Wallis test, Pairwise comparison bet. each 2 groups was done using Post Hoc Test (Dunn's for multiple comparisons test)

p: p value for comparing between the studied groups

p_1: p value for comparing between **normal individuals** and **iron deficiency anemia**

p_2: p value for comparing between **normal individuals** and **other type of anemia**

p_3: p value for comparing between **iron deficiency anemia** and **other type of anemia**

*: Statistically significant at $p \leq 0.05$

Table (7):Comparison between the three studied groups according to retics, ferritin, blood glucose and HbA1c:

	Group I(n = 30)	**Group II(n = 30)**	**Group III(n = 30)**	**H**	**p**
Retics					
Min. – Max.	0.56 – 2.47	0.02 – 0.64	0.03 – 0.80	58.536*	<0.001*
Mean ± SD.	1.54 ± 0.47	0.27 ± 0.19	0.26 ± 0.25		
Median (IQR)	1.46 (1.19 – 1.92)	0.22 (0.10 – 0.41)	0.15 (0.08 – 0.53)		
Sig. bet. grps.	p_1<0.001*,p_2<0.001*,p_3=0.649				
Ferritin					
Min. – Max.	26.0 – 250.0	4.0 – 45.0	12.0 – 267.0	33.692*	<0.001*
Mean ± SD.	111.7 ± 72.37	26.17 ± 14.36	114.4 ± 74.40		
Median (IQR)	111.0 (43.0 – 160.0)	29.0 (11.0 – 39.0)	109.5 (62.0 – 172.0)		

Sig. bet. grps.	$p_1<0.001^*, p_2=0.976, p_3<0.001^*$				
FBG					
Min. – Max.	72.0 – 97.0	70.0 – 97.0	72.0 – 98.0	0.043	0.958
Mean ± SD.	83.27 ± 6.64	83.40 ± 8.20	83.80 ± 7.16		
Median (IQR)	83.0 (81.0 – 88.0)	82.0 (76.0 – 90.0)	83.0 (77.0 – 86.0)		
HbA1c		**Before**			
Min. – Max.	3.90 – 5.40	5.50 – 6.20	4.0 – 5.40	81.230^*	$<0.001^*$
Mean ± SD.	4.58 ± 0.51	5.90 ± 0.19	4.72 ± 0.53		
Median (IQR)	4.40 (4.10 – 5.10)	5.90 (5.70 – 6.10)	4.80 (4.20 – 5.30)		
Sig. bet. grps.	$p_1<0.001^*, p_2=0.456, p_3<0.001^*$				
	Iron deficiency anemia				

H: H for Kruskal Wallis test, Pairwise comparison bet. each 2 groups was done using Post Hoc Test (Dunn's for multiple comparisons test)

p: p value for comparing between the studied groups

p_1: p value for comparing between **normal individuals** and **iron deficiency anemia**

p_2: p value for comparing between **normal individuals** and **other type of anemia**

p_3: p value for comparing between **iron deficiency anemia** and **other type of anemia**

*: Statistically significant at $p \leq 0.05$

Table (8):Comparison between the two periods according to HbA1c in Iron deficiency anemia (n = 30)

HbA1c	**Before (n = 30)**	**After (n = 30)**	**t**	**p**
Min. – Max.	5.50 – 6.20	4.90 – 5.60	18.311^*	$<0.001^*$
Mean ± SD.	5.90 ± 0.19	5.33 ± 0.18		

Median (IQR)	5.90 (5.70 – 6.10)	5.35 (5.20 – 5.50)		

t: Paired t-test

p: p value for comparing between **before** and **after**

*: Statistically significant at $p \leq 0.05$

Table (9):Comparison between the three studied groups according to HbA1c

Sugar picture	**Group I (n = 30)**	**Group II (n = 30)**	**Group III (n = 30)**	**F**	**p**
HbA1c		**After**			
Min. – Max.	3.90 – 5.40	4.90 – 5.60	4.0 – 5.40	24.779	<0.001*
Mean ± SD.	4.58 ± 0.51	5.33 ± 0.18	4.72 ± 0.53		
Median (IQR)	4.40 (4.10 – 5.10)	5.35 (5.20 – 5.50)	4.80 (4.20 – 5.30)		
Sig. bet. grps.	p_1<0.001*,p_2=0.454,p_3<0.001*				

F: F for ANOVA test, Pairwise comparison bet. each 2 groups was done using Post Hoc Test (Tukey)

p: p value for comparing between the studied groups

p_1: p value for comparing between **normal individuals** and **iron deficiency anemia**

p_2: p value for comparing between **normal individuals** and **other type of anemia**

p_3: p value for comparing between **iron deficiency anemia** and **other type of anemia**

*: Statistically significant at $p \leq 0.05$

Table (10):Comparison between the three studied groups according to iron profile

	Group I (n = 30)	**Group II (n = 30)**	**Group III (n = 30)**	**F**	**p**
TIBC					
Min. – Max.	243.0 – 444.0	461.0 – 600.0	257.0 – 446.0	103.448*	<0.001*
Mean ± SD.	357.7 ± 56.46	534.1 ± 47.23	369.4 ± 55.17		

Median (IQR)	357.0 (311.0 – 412.0)	529.5 (496.0 – 586.0)	371.5 (320.0 – 416.0)		
Sig. bet. grps.	$p_1<0.001^*, p_2= 0.673, p_3<0.001^*$				
Transferrin saturation (%)					
Min. – Max.	20.0 – 50.0	1.0 – 25.0	20.0 – 47.0	72.665^*	$<0.001^*$
Mean ± SD.	34.70 ± 9.67	11.40 ± 6.91	32.63 ± 8.05		
Median (IQR)	36.0 (25.0 – 42.0)	10.0 (6.0 – 16.0)	31.50 (27.0 – 39.0)		
Sig. bet. grps.	$p_1<0.001^*, p_2= 0.600, p_3<0.001^*$				

F: F for ANOVA test, Pairwise comparison bet. each 2 groups was done using Post Hoc Test (Tukey)

p: p value for comparing between the studied groups

p_1: p value for comparing between **normal individuals** and **iron deficiency anemia**

p_2: p value for comparing between **normal individuals** and **other type of anemia**

p_3: p value for comparing between **iron deficiency anemia** and **other type of anemia**

*: Statistically significant at $p \leq 0.05$

IV. DISCUSSION:

In the current study there was no significant difference between the studied groups as regard baseline data. **Intra et al.**[6] who conducted a retrospective case-control study to determine the effects of iron deficiency on HbA1c levels. Starting with the large computerized database of the Italian Hospital of Desio, including data from 2000 to 2016, they described the recruited population by that 3,942 consecutive nonpregnant individuals aged between 12 and 98 years with at least one HbA1c measurement, complete blood cells count, fasting blood glucose and ferritin values during the same date of blood collection were enrolled. Of these, 1,111 subjects were excluded, as described above. The final group consisted of 2,831 nondiabetic individuals, 1,508 males (53%) and 1,323 females (47%).

Solomon et al.[7] who conducted a facility based comparative cross sectional study in Ethiopia on 174 diabetic patients (87 with iron deficiency anemia and 87 without, Out of 174 diabetic patients, 89(51.1%) were male and 85 (48.9%) were female. The mean age was 47.5±15.83. A total of 87 patients diagnosed with IDA were involved in the study, where 53 (60.9%) were male and 34 (39.1%) were female. Of the 87 non-IDA diabetic patients, 51 (58.6%) were female and 36 (41.4%) were male.

The present study showed that there was high significant difference between healthy control, iron deficiency anemia and non iron deficiency anemia as regard HbA1c, with the highest level of HbA1c in iron deficiency anemia group.

This was in the same side with what stated by **Solomonet al.**[7] who illustrated that The mean RBC, MCV, MCH, MCHC, RDW were 3.45 ± 0.8, 88.57 ± 8.56, 29.89 ± 4.04, 32.97 ± 2.19, 3.45 ± 0.80 respectively. Pearson correlation test was used to determine the association between HbA1C and hematological parameters of the IDA patients. HbA1C was statistically non-significant with RBC, MCV, MCH, MCHC.

This was in agreement with **Manish et al.**[8]who revealed that Among the hematological parameters; RBC, Hgb, MCV, MCH showed statistically significant mean difference between the iron deficiency and control groups

Christy et al.[9] concluded that a positive correlation between iron deficiency anemia and increased A1C levels, especially in the controlled diabetic women and individuals having FPG between 100-126 mg/dl. Hence, before altering the treatment regimen for diabetic patient, presence of iron deficiency anemia should be considered.

Koga et al. [10]found that red cell counts and A1C were associated positively, while A1C and red cell indices as well as hemoglobin were associated negatively in nondiabetic premenopausal women. In addition, post menopausal women did not show any significant association.

In a study carried out by **Hashimoto et al.**[11] A1C levels were elevated in pregnant diabetic women. Pregnancy is another condition which can cause spurious A1C elevation. Pregnancy is mostly associated with iron deficiency anemia. The study showed that it was iron deficiency anemia which caused elevated A1C, and not pregnancy itself.

On the contradict **Goldstein et al.** [12] demonstrated that HbA1c measured by HPLC was increased two hours after a standard breakfast and incubating the red cell in 0.9% saline at 37°C for five hours eliminated this increment. which was explained by presence of labile HbA1c. This effect was eliminated by reagents used in newer enzymatic kits.But **Rai and Pattabiraman.**[13] conducted a study to evaluate different methods used to analyze HbA1c and found no significant difference between them.

Grossmanet al.[14] found that the exact mechanism underlying the IDA effects on HbA1c values is still unclear. A state of iron deficiency affects the lifespan of red blood cells, and the erythrocytes count is decreased, leading to an older population of red blood cells that are in contact with plasma glucose longer, causing falsely higher HbA1c measurements

In the current study there was a high significant difference between the before and after treatment in iron deficiency group as regard HbA1c.

Kumar and Nutakki,[15]verified that the mean HbA1c levels were significantly lower in patients after 2 months of treatment than in the controls (P0.05).

Silva, et al.[16] conducted a study on Effect of iron deficiency anemia on HbA1c levels is dependent on the degree of anemia with 122 patients. They concluded that IDA affects HbA1c results and this effect is dependent on

anemia degree. These upward changes are statistically significant but they may not clinically relevant when the overall variability of the HbA1c test is considered. Also**Bhardwaj et al.**[17] illustrated that The mean baseline HbA1c level in anaemic patients (6.60) was significantly higher than that of controls (5.48). However, after 3 months of treatment, significan decline from 6.60 to 5.74 was found in HbA1c levels.

Attard, et al.[18]conducted an analysis from the China Health and Nutrition Survey, a longitudinal population based study. This analysis included 7308 adults. And they found potential misclassification of diabetes using HbA1c in areas of endemic Iron Deficiency anemia. Estimating diabetes prevalence using HbA1c may result in under diagnosis in women with ID and over diagnosis in men with anemia.

Kim, et al.[19] studied on Diagnosing Diabetes with Haemoglobin A1c: Current debates and considerations for anaemic patients. They concluded that HbA1c is a convenient new measure for diagnosing diabetes. Clinicians should determine the suitability of HbA1c for diagnostic purposes and their specific setting with consideration of the various epidemiologic factors and conditions that can affect its measurement

Nitin.[20] studied on HbA1c and factors other than diabetes mellitus affecting it. They concluded that HbA1c is not affected by blood sugar levels alone, and there are various confounding factors when measuring HbA1c. It is hence prudent to rule out all other confounding factors before making a therapeutic decision based on the HbA1c levels. Also, the effects of iron deficiency and Vitamin B12 deficiency on HbA1c should be studied in greater detail.

Shanthi, et al.[21]conducted a study on Effect of Iron Deficiency on Glycation of Haemoglobin in Non diabetics in 75 patients. They concluded that HbA1c is not affected by the blood sugar levels alone, and there are various confounding factors when HbA1c is measured, especially that of iron deficiency, which is the commonest of the deficiency diseases worldwide. It is hence prudent to rule out IDA before making a therapeutic decision, based on the HbA1c levels.This was in agreement with **Sinha et al.** [22]who stated that HbA1c levels and absolute HbA1c levels increased with treatment of iron deficiency anemia. That could be attributable to nutritional deficiency and/or certain unknown variables.

In the present study there was high significant difference between healthy control, iron deficiency anemia and non iron deficiency anemia as regard serum iron, TIBC and Transferrin saturation.

This was in concordant with **Intra et al.**[6] who stated that there were differences in the mean levels of hematological and biochemical parameters between subjects affected by IDA and controls, hemoglobin, hematocrit, red blood cell count, MCV, MCH, MCHC, and ferritin values were lower in iron-deficient subject.

This was in agreement with **Solomon et al.**[7] who reported that the mean RBC, Hgb, HCT, MCV, MCH, MCHC, HbA1c were significantly lower in IDA group compared to the control group

This was in concordant with**Kumar and Nutakki,**[15]who noticed that the mean baseline serum iron levels were significantly lower in patients than in controls ($p<0.01$)

In this thesis we found there was high significant difference between the studied groups as regard reticulocyte count and ferritin.

This was in agreement with **Kumar and Nutakki,**[15]who found that The mean baseline serum ferritin levels were significantly lower in patients than in controls.

This was in concordant with **Sinha et al.**[22] who demonstrated that The mean baseline serum ferritin levels were significantly lower in patients than in control, they also stated that the mean hemoglobin and mean serum ferritin levels increased in anemia patients over 2 months of iron treatment.

In this study we demonstrated that there was no significant difference between the studied groups as regard FBG or PPG.

Christy et al.[9]showed that conditions such as iron deficiency anemia can spuriously elevate A1C levels; consequently care should be taken before altering treatment regimen. Our observation also showed significantly higher A1C levels in anemic patients who had FPG between 100-126 mg/dl. As a result, anemia may exaggerate the picture of glycemic status in this group of patients.

V. CONCLUSION:

There is significant relation between HbA1c and iron deficiency anemia while there is no relation between iron deficiency anemia and Fasting blood sugar or Post prandial sugar, Iron deficiency anemia elevates HbA1c levels in non-diabetic individuals.

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