Section: Medicine

Original Research Article

ASSOCIATION OF INSULIN RESISTANCE WITH HAEMATOLOGICAL PARAMETERS IN SEMI URBAN PRE- DIABETIC POPULATION OF SOUTH DELHI –AN EMERGING LINK

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ABSTRACT

Background: There is an insufficient data on the relationship between Insulin Resistance with hematological parameters in pre-diabetic population.
Objective: To establish or analyze relationship between IR and hematological parameters in Pre-diabetes who are at risk of developing type 2 DM. To find out whether the association between hematological parameters and pre-Diabetic states are stronger in women and men.
Materials and Methods: A cross-sectional study on 200 patients was conducted in the medicine outpatient unit of HAHC Hospital, Jamia Hamdard Tertiary care centre. Pre-diabetic patients were selected as per the ADA criteria and sera from healthy individuals will serve as control.
Results: There was insignificant correlation between HOMA-IR and WBC of the hematological parameters. Hematological changes in diabetes can be caused by several factors including increased production of reactive oxygen species (ROS) and the formation of advanced glycation end products (AGEs) as a result of long-term hyperglycaemia.
Conclusion: The alterations in hematological parameters could be included as a new and indirect marker of the IR. This study focuses on hematological parameters as surrogate markers for identifying IR in Pre-diabetes stage in both males and females.
Keywords: IR- Insulin resistance, DM- diabetes mellitus, HOMA - Homeostasis model of assessment, RBC- Red blood cell count, WBC – White Blood Cell, HB- Hemoglobin, MCH - Mean corpuscular Hb, MS- Metabolic syndrome, TNF-α-Tumor necrosis factor α, IL-6-interleukin-6, NF¬κB-nuclearfactor-kappaB.

INTRODUCTION

Diabetes mellitus (DM) is a metabolic disorder that arises from insulin secretion, insulin action, or both. Insulin deficiency, in turn, contributes to chronic hyperglycaemia with disturbances of carbohydrate, fat, and protein metabolism.[1] It results in a major health problem that has been widely increasing over the past few decades.

By 2045, it is predicted that more than 628.6 million adults will have diabetes due to the disease's rising prevalence. Insulin resistance (IR) is accepted to be a major risk factor in the etiology of Type 2 DM, hypertension, dyslipidemia, atherosclerotic vascular disease, coronary heart disease and stroke.[2] Even in individuals with normal oral glucose tolerance test, IR is a strong predictor of Type 2 DM. Therefore it is important to validate IR in the pre-diabetes stage when therapeutic intervention is likely to be more successful.[3]

The gold standard methods designed to measure insulin sensitivity: the hyperinsulinemic euglycemic clamp and the frequently sampled intravenous glucose tolerance test are complex and impractical

in the clinical settings.[4,5] Even simpler methods such as the homeostasis model assessment of IR (HOMA-IR) and several other indices proposed till date have certain limitations.[6]

For so many years, the relationship between IR and type 2 DM has been studied. It has been discovered that IR is not only the most powerful predictor for development of type 2 DM in future but it can also be used as a therapeutic target once blood glucose levels are raised.[7] Individuals with impaired fasting glucose (IFG) and/or impaired glucose tolerance (IGT) have been referred to as having pre-diabetes.[8]

There is an urgent need to identify more individuals who are undiagnosed or those who are at risk for diabetes so that timely intervention could be done. Studies have shown that hematological parameters which are routinely measured such as White Blood Cell (WBC) count and hematocrit (hct) levels are associated with IR and type 2 DM. The pathophysiological mechanisms by which hematological parameters could influence glucose metabolism are not entirely understood.

Prior studies have also suggested that haematocrit could be related to IR as it is positively correlated with hyperinsulinemia and risk factors associated with IR, e.g. obesity, high blood pressure, elevated serum triglycerides and low HDL cholesterol. Also, it has been seen that hematocrit is associated with blood viscosity which also plays a role in development of IR. Moreover, chronic inflammation plays a role in pathogenesis of type 2DM, therefore it will not be out of context to think an association between total WBC Count and diabetes risk factors as WBC count is a non-specific marker of inflammation.[9,10,11,12] Also, several studies have already demonstrated that insulin regulates erythropoiesis in vitro.[13] Recent studies have also shown that hyperinsulinemia in erythroid progenitors could lead to an increase in red blood cell (RBC) and white blood cell (WBC) count count.[14] There is evidence that insulin increases the Trans capillary movement of albumin and as a result the plasma volume decreases and HCT increases.[15]

To the best of our knowledge we have limited data from studies involving larger community-based samples assessing a possible link between hematological parameters and IR.

The need of the hour is to develop a surrogate marker to measure IR that is easy to implement clinically and that is suitable for large epidemiological studies. Therefore, the present study is formulated to focus on relationship of hematological parameters with IR and to assess whether they can be used as candidate markers for gauging IR in pre-diabetic individuals who would benefit most from early interventions in a subgroup of pre-diabetic population.

MATERIALS AND METHODS

Study Design: Cross-sectional observational study

Study Group: Patients diagnosed with pre-diabetes (both males and females aged 25- 65 years) seeking medical care at a tertiary care hospital in New Delhi.

Sample size: One hundred patients

Duration of study: Four months

Operational definitions: Pre-diabetic diagnosis was made by American Diabetic Association (ADA) criteria. Patients were categorised into normal healthy control groups and Pre-diabetics based on their Blood glucose Fasting, Blood glucose PP and HbA1c analysis.

Consent (informed) was taken from the patients. Our study was approved by Institutional ethics committee. The identity of patients was not revealed as data has been used in anonymized form.

Baseline Data collection

For each subjects, demographic data were taken. Furthermore, the clinical findings of patients during hospitalization and routine investigations (hematological and biochemical) were gathered from electronic medical records. A history of Subjects diagnosed with pre-diabetes as per ADA criteria,[4] HbA1c $\leq 6.5 \pm 0.3\%$ or, Fasting plasma glucose 100 to125 mg/dl. Fasting is defined as no caloric intake for at least 8 hours or, Two-hour plasma glucose 140 to 199 mg/dl. Controls with no history of diabetes and fasting blood glucose levels between 70 – 100 mg/dl were included. Sera from individuals (n=100) was matched for age, gender and socio-economic conditions were included.

Subjects with apparent hepatic, pulmonary and renal malignancies, Immunologic disorders, Infectious disorders, Hematologic diseases with WBC >15,000/mm^3 were not taken. Subjects on steroids, immunosuppressant, hem dialysis or erythropoietin therapy were excluded

Patients with fasting blood glucose ≥ 126 mg/dl or 2 hrs. Plasma glucose ≥ 200mg/dl (i.e., diabetes mellitus) were excluded.

Blood samples were drawn before starting the treatment. The samples were tested for complete blood count (CBC) on six-part haematology analyser (Sysmex XN-1000). Biochemical investigations blood sugar fasting and 2-hr PP was done on Beckman coulter AU-480 and HbA1c Analysis was done on Bio-Rad D-10 and serum fasting insulin analysis was done on Abbott Architect i1000sr.

The degree of IR was determined using the homeostasis model assessment (HOMA-IR). The estimate of IR by homeostasis model assessment (HOMA) was calculated with the formula: [fasting serum insulin (µUI/ml) x fasting plasma glucose (mg/dl) x 0.0551] / 22.5.[6]

All data were recorded in a pre-designed proforma. Patients with incomplete information on medical records and those who sought transfer to other medical facilities were excluded from our study.

Statistical Analysis

Data were systematically collected and compiled. Mean value of variables were compared against normal ranges, and observation were tabulated and expressed as mean ± standard deviation was applied to P<0.05 was considered statistically significant. We calculated the standard error of mean also. Data was analysed using IBM SPSS statistics for windows, version 26 (IBM Corp, Armonk, N.Y., USA)

Correlation among IR, insulin levels and hematological parameters was done using Karl Pearson correlation of coefficient (r value).

RESULTS

One hundred patients with confirmed pre-diabetes were taken in our study.

Demographic characteristics of the study population.

Out of 100 pre-diabetic subjects 28% were males and 72% were females. The mean age group of this study was found to be 42 years. There was no significant correlation was found between age, gender distribution, body weight and duration of diabetes. As per the cut off values of HOMA-IR' the pre-diabetic subjects were divided into insulin resistant and insulin sensitive groups. (Table 1, figure1 and figure 2)

The levels of Blood sugar fasting levels were significantly higher in subjects with pre-diabetes as compared to control group. The mean glucose levels were 109.4 ± 0.7560 mg/dL in pre-diabetics whereas in control groups average glucose levels were 89.65 ± 0.8957. P-value <0.05 is considered as statistically significant. [Figure 3, Table 2] The levels of HbA1C were significantly higher in subjects with pre - diabetics as compared to control group. The mean HbA1C levels were 5.986 ± 0.03333 % in pre-diabetics whereas in control groups average HbA1C levels were 4.608 ± 0.07980 %. P-value <0.05 is considered significant. [Figure 4, Table 3] The HOMA-IR levels were significantly higher in subjects with pre-diabetics. Mean insulin resistance was 3.310 ± 0.2902 where as in control groups mean insulin resistance value was 2.018 ± 0.2040. A significant difference between the two groups is 1.038 ± 0.3859, p-value < 0.05 (Figure5, Table 4). The WBC Count were significantly higher in subjects with pre-diabetics. Mean WBC Count was 8.435 ± 0.2417 × 10 3 /µl where as in control group, mean WBC count value was7.409 ± 0.2500× 10 3/ µl. A significant difference between the two groups is 1.038 ± 0.3859, p-value < 0.005 (Figure 6, Table 5). The RBC Count was not significantly higher in subjects with pre-diabetics. Mean RBC Count was 4.314 ± 0.08292 whereas in control groups mean RBC Count Was 4.485 ± 0.1106 (Figure 7, Table 6). The Hb level were not significantly higher in subjects with pre-diabetics. The mean Hb levels was 11.73 ± 0.2447 g/dl whereas in control groups mean Hb levels was 12.14 ± 0.2607 g/dl. There was no significant difference in hemoglobin levels. [Figure 8, Table 7] The MCH level were not significantly higher in subjects with pre-diabetics. Mean MCH levels was 38.41 ± 0.6702 g/dl whereas in control groups mean MCH levels was 38.86 ± 0.6568 g/dl. There was no significant difference in MCH levels. [Figure 9, Table 8]

Correlation of HOMA-IR with hematological parameters between insulin resistance and insulin sensitive groups:

Cut off values of HOMA-IR is used to divide subjects into insulin resistant (>1.82) and insulin sensitive (< 1.82) groups among the pre-diabetics. Further, independent t-test is applied between both the groups and p-value was found to be statistically significant (<0.005). [Table 10]

The WBC Count were non-significantly higher in subjects with insulin resistant group, Mean WBC Count was 8.35 ± 0.375× 10 3 /µl where as in insulin resistant groups mean WBC count value was 8.24 ± 0.327× 10 3/ µl. The difference between the two groups is non-significant (p-value 0.824). The RBC Count were non-significantly higher in subjects with insulin resistant group. Mean RBC Count was 4.42 ± 0.125× 10 6/ µl were as in insulin sensitive groups, mean WBC count value was 4.25 ± 0.110×10 6/ µl. The difference between the two groups is non-significant (p-value 0.335). The Hb Count were non-significantly higher in subjects with insulin sensitive group, Mean Hb Count was 11.95 ± 0.451g/dl where as in insulin resistant groups mean Hb count value was 11.62 ± 0.294g/dl. The difference between the two groups is non-significant (p-value0.534). The MCHC Count were non-significantly higher in subjects with insulin resistant. Mean MCHC Count was 39.08 ± 1.127g/dl where as in insulin sensitive groups mean MCHC count value was 38.06 ± 0.849g/dl. The difference between the two groups is non-significant (p-value 0.474)

Correlation of HOMA-IR with hematological parameters in pre-diabetic subjects

HOMA-IR was seen to be increased with fasting insulin in Pre -diabetic patients. Further Fasting insulin shows a significant positive correlation with HOMA-IR (p=0.002, r=0.93) (Figure 10). HOMA-IR was seen to be increased with HbA1c in Pre - diabetic patients. Further Fasting insulin shows an insignificant positive correlation with HOMA-IR (p= 0.003, r=0.02). [Figure 11] HOMA-IR was seen to be decreased with hemoglobin in pre-diabetic patients. Further, fasting insulin shows an insignificant negative correlation with HOMA-IR (r= -0.32, p=0.73) (Figure 12). HOMA-IR was seen to be increased with WBC in pre-diabetic patients. Furthermore, WBC count shows an insignificant positive correlation with HOMA-IR (r= 0.04, p=0.68). [Figure 13] HOMA-IR was seen to be increased with RBC in pre-diabetic patients. Moreover, RBC showed an insignificant positive correlation with HOMA-IR (p= 0.33, r=0.02). (Figure 14). HOMA-IR was seen to be increased

with MCH in pre-diabetic patients. Also, MCH showed an insignificant positive correlation with HOMA-IR (r= 0.019, p=0.83). [Figure 15]

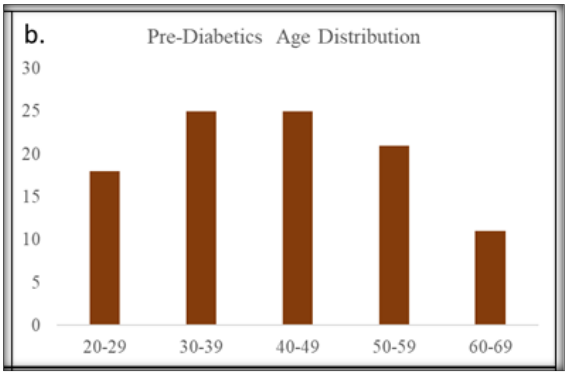

Figure 1: Age wise distribution of subjects

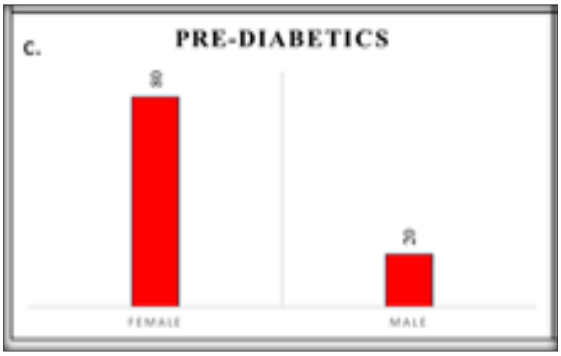

Figure 2: sex wise distribution (%)of study subjects

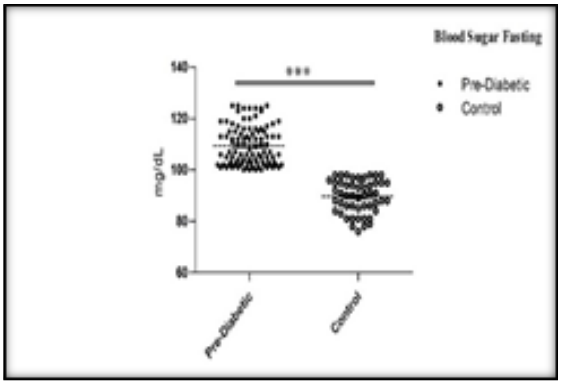

Figure 3: Difference between pre-diabetic and healthy control in terms of blood sugar

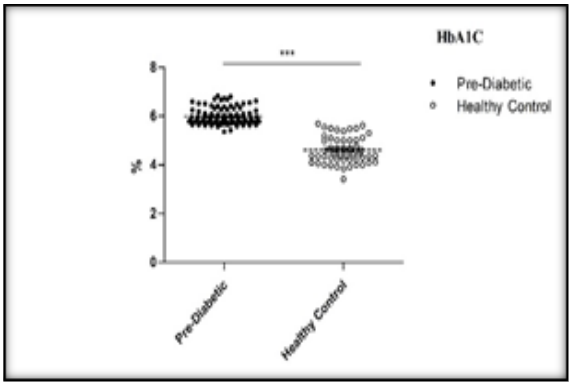

Figure 4: Differences between Pre-diabetic and Healthy controls in terms of HbA1C levels

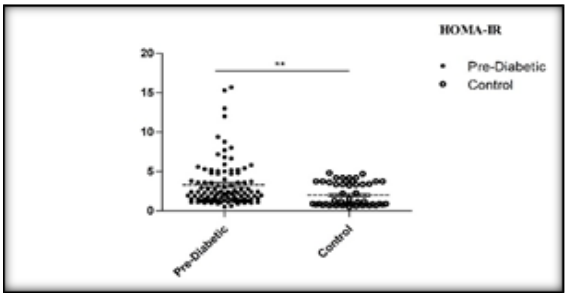

Figure 5: Differences between Pre-diabetic and Healthy controls in terms of HOMA-IR levels

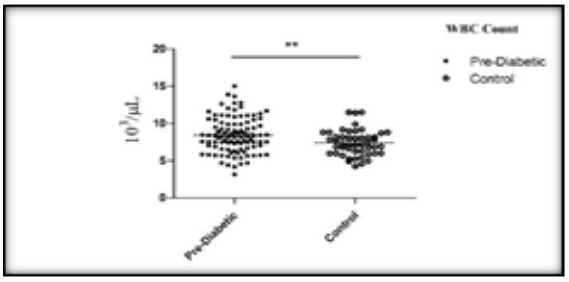

Figure 6: Differences between Pre-diabetic and Healthy controls in terms of WBC levels

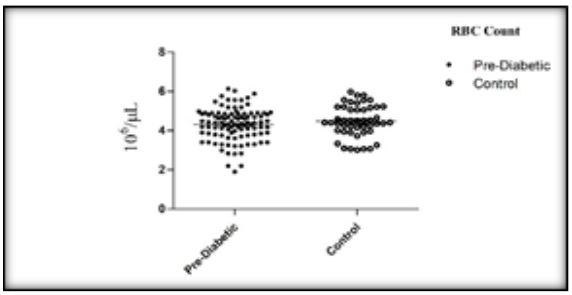

Figure 7: Differences between Pre-diabetic and Healthy controls in terms of RBC Count

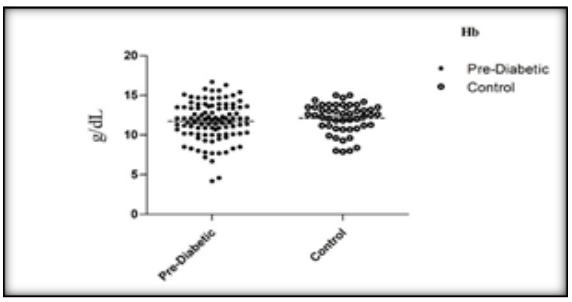

Figure 8: Differences between Pre-diabetic and Healthy controls in terms of HB Count

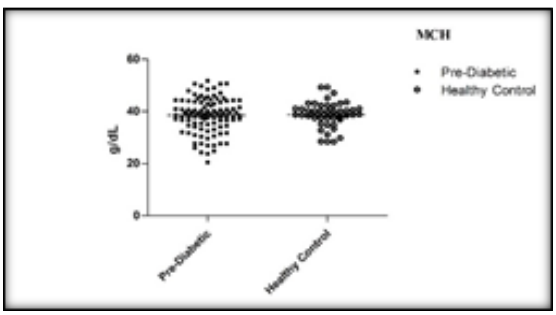

Figure 9: Differences between Pre-diabetic and Healthy controls in terms of MCH Count

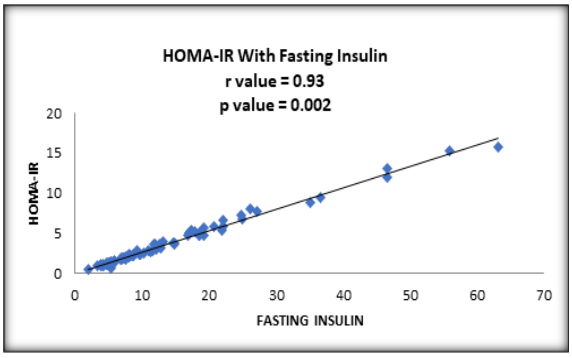

Figure 10: Correlation analysis (Karl Pearson correlation coefficient) showing the relation between Fasting plasma insulin and HOMA-IR in Pre-Diabetic subjects

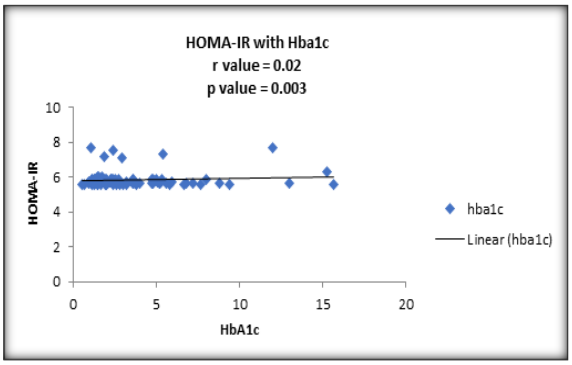

Figure 11: Correlation analysis (Karl Pearson correlation coefficient) showing the relation between HbA1C and HOMA-IR in Pre-Diabetic subjects

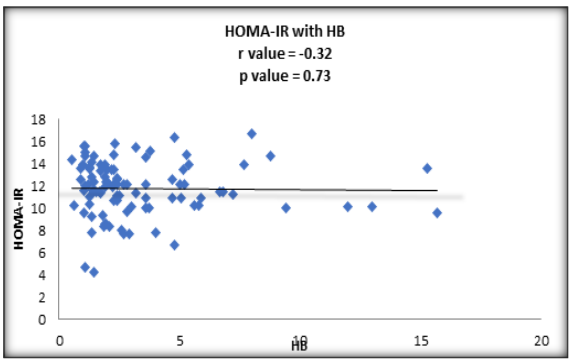

Figure 12: Correlation analysis (Karl Pearson correlation coefficient) showing the relation between Hb and HOMA-IR in Pre-Diabetic subjects

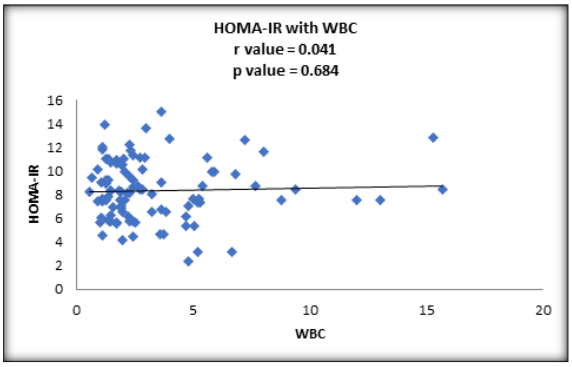

Figure 13: Correlation analysis (Karl Pearson correlation coefficient) showing the relation between WBC and HOMA-IR in Pre-Diabetic subjects

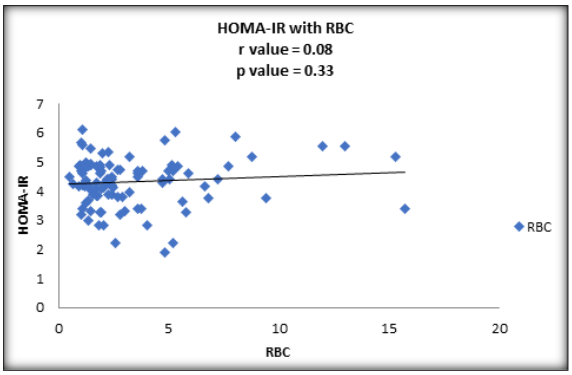

Figure 14: Correlation analysis (Karl Pearson correlation coefficient) showing the relation between RBC and HOMA-IR in Pre-Diabetic subjects

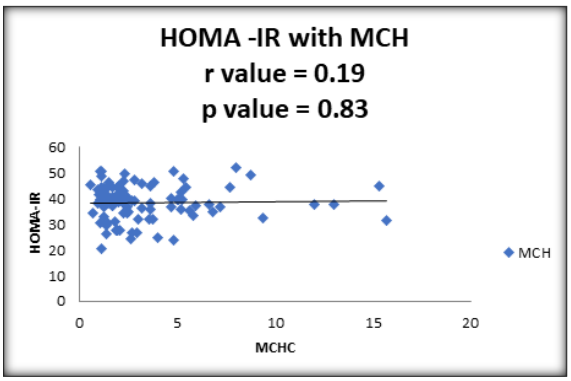

Figure 15: Correlation analysis (Karl Pearson correlation coefficient) showing the relation between MCHC and HOMA-IR in Pre-Diabetic subjects

Table 1: Socio-demographic features of the study subjects

	Pre-diabetic group (n= 100)
Age (years) (mean ± SEM)	42.72 ± 1.215
Gender Distribution (n)	Male = 28 Female = 72
Insulin resistant	64
Insulin sensitive	35

Table 2: Comparison of mean fasting blood glucose between pre-diabetic and healthy control groups

Parameter	**Pre- diabetics**	**control**	**p- value**
BSF (mean ± SEM)	109.4 ± 0.7560	89.65 ± 0.8957	< 0.0001

Table 3: comparison of mean HbA1c Levels between pre-diabetics and control

Parameters	Pre- diabetics	control	p-value
HbA1C (%) (mean ± SEM)	5.986 ± 0.03333	4.608 ± 0.07980	0.0003

Table 4: Comparison of mean HOMA-IR levels between Pre-diabetics and control

Parameter	Pre- diabetics	Control	p-value
HOMA-IR (mean ± SEM)	3.310 ± 0.2902	2.018 ± 0.2040	0.0034

Table 5: Comparison of mean White Blood Cells Count between Pre-diabetic and control

Parameter	Pre- diabetics	Control	p-value
WBC Count ($\times 10^{3}$/µl) (mean ± SEM)	8.435 ± 0.2417	5.409 ± 0.250	0.009

Table 6: Comparison of mean White Blood Cells Count between Pre-diabetic and control

Parameter	Pre- diabetics	Control	p-value
RBC Count (mean±SEM)	$4.314 \pm 0.08292 \times 10^{6}$	$4.485 \pm 0.1106 \times 10^{6}$	0.2279

Table 7: Differences between Pre-diabetic and Healthy controls in terms of HB Count

Parameter	Pre-diabetics	control	p- value
Hb (g/dl) (mean ± SEM)	11.73 ± 0.2447	12.14 ± 0.2607	0.3038

Figure 8: Differences between Pre-diabetic and Healthy controls in terms of MCH Count

Parameter	Pre –diabetic	control	p-value
MCH (g/dl) (mean ± SEM)	11.73 ± 0.2447	12.14 ± 0.2607	0.6684

Table 9: Correlation of Hematological Parameters between Insulin Resistance and Insulin Sensitive Groups

	Insulin sensitive groups (n= 35) Mean ± SEM	**Insulin resistant groups** (n=64) Mean ± SEM	**p- value**
WBC	8.24 ± 0.327	8.35 ± 0.375	0.824
RBC	4.25± 0.110	4.42 ± 0.125	0.335
HB	11.95 ± 0.451	11.62 ± 0.294	0.534
MCH	38.06 ± 0.849	39.08 ± 1.127	0.474

DISCUSSION

In our study, it was seen that the levels of blood sugar fasting levels were significantly higher in subjects with pre-diabetes as compared to control group because insulin resistance occurred before chronic hyperglycaemia.[16] The difference from insulin resistance in the pre-diabetic state result from oxidative stress caused by increased glucose levels. Insulin fasting further showed strong positive correlation with HOMA-IR. Hyperglycaemia promotes the overproduction of ROS, which activate several pathways including the polyol and hexosamine pathway, protein kinase C (PKC) pathway, NF¬κB-mediated vascular inflammation and formation of advanced glycation end-products (AGEs).[17,18] Activation of the PKC pathway leads to changes in vascular cells, including permeability, inflammation, angiogenesis, cell growth and apoptosis.[19] Hyperglycaemia can also induce epigenetic changes in the NF¬κB pathway.[20,21] AGE-modified extracellular matrix proteins can bind to the receptor for AGEs and contribute to the progression of diabetic complications, such as retinopathy, nephropathy and cardiovascular disease.[22]

In our study, HbA1C levels were significantly higher in subjects with pre-diabetes as compared to control group. Furthermore, HbA1c shows weak positive correlation with HOMA-IR. Our results also correlated with other studies which showed that this might be due to the non-enzymatic glycation binding of free aldehyde groups of carbohydrates to unprotonated free amino groups of proteins.[23] The development of HbA1c is caused by the binding of glucose molecules to potential glycation sites in hemoglobin molecules. Hemoglobin A generates a labile intermediate adduct by condensation with glucose, which is then rearranged to the more stable ketamine adduct (HbA1c) form.[24] pH, inorganic phosphate, oxidative stress, deglycation, and Schiff base inhibitors are among physiological variables that can influence the rate of HbA1c production.[25-29] A phenomenon known as oxidative stress has been linked to the multifactorial aetiology of insulin resistance. The degree of insulin resistance was found to be linked with plasma markers of oxidative stress.[30,31]

In our study, the WBC count was insignificantly higher in subjects with pre-diabetics. In insulin resistance group also, WBC Count were significantly higher in subjects as compared to insulin sensitive group and it was found to be statistically insignificant. Furthermore, WBC showed insignificant weak positive correlation with HOMA-IR. Among the hematological parameters,

the most widely associated with the diabetes is WBC count. This significantly higher WBC count in the pre-diabetic group is indicative of the inflammation due to high glucose. The association of WBC count with insulin resistant was very strong in diabetics because WBC is a component of inflammatory process. One possible explanation is that both a higher WBC and insulin resistance reflect an underlying activation of the immune system. It was shown, for instance, that interleukin-6 (IL-6), a potent white blood cell differentiation factor,[33] that is produced mostly in adipose tissue is associated with insulin resistance.[34, 35] Therefore, it could be hypothesized that IL-6 may be a factor that not only increases WBC but also causes insulin resistance. This notion is also supported by an observation that a single nucleotide polymorphism in the IL-6 gene was shown to be associated with an increased WBC count and lower insulin sensitivity.[36] Interestingly, it has been shown that WBC and other markers of inflammation aggregate in families, which suggests that genetic factors may be involved in the activation of the immune system.[37] However, because relatives share not only genetic determinants but also environmental factors, such as exposure to infection, it is not possible to determine whether familiar associations are genetic or environmental. Because cytokines, such as IL-6, are produced by activated white blood cells, it is also possible that an activation of the immune system, caused by inflammation, could increase WBC and therefore cytokine production,[38,39] which may decrease insulin sensitivity.[38] Hormones are another possible link between WBC and insulin sensitivity.

In our study, the RBC Count was insignificantly associated with HOMA-IR in pre-diabetics when compared with normal healthy individuals. The RBC Count was insignificantly higher in subjects with insulin resistant as compared to insulin sensitive groups. Moreover, RBC count showed insignificant weak positive correlation with HOMA-IR.

However, our study correlated with other studies and showed the same trend. This occurs when blood glucose increases, the shape and function of RBC changes, deformability decreases, and ability to pass the capillaries decreases, RBC aggregates, blood viscosity increases, and capillary resistance increases.[40,41] The super physiological dose of insulin combined with the red blood cell insulin receptor will increase the micro viscosity of red blood cells, leading to the aggregation of red blood cells and the increase of blood viscosity.[42,43] Hyperinsulinism activates phosphodiesterase-3 in human red blood cells, impairing the release of adenosine triphosphate (ATP), leading to impaired red blood cell energy supply.[44] Insulin resistance increases the secretion of red blood cell vesicles; and these vesicles which are rich in damaged red blood cell components, preferentially combine with circulating white blood cells and change their functions.[45] In addition, vesicles derived from red blood cells can promote the production of inflammatory cytokines, promote the efficacy of antigen-presenting cells, induce the proliferation of CD4 + T and CD8 + T lymphocytes, and produce pro-inflammatory effects.[46] Insulin resistance, red blood cell dysfunction, oxidative stress damage, and increased oxidative stress products are associated with the pre-diabetes period.[47,48]

Decrease insulin secretion should be caused by the oxidative stress.[49] Hyperglycaemia, results in troubles in cellular metabolism due to enhanced generation of reactive oxygen species (ROS) and non-enzymatic glycation of many macromolecules, which lead to changes cellular structure and function, as well as the arrangement of glycation end products (AGEs). The formation of AGEs enhances metabolic disturbances and also increases reactive oxygen species production via interplay with the specific receptor for AGE (RAGE); This causes changes in structure and the basement membrane's biophysical properties produce changes in permeability and vasodilation of blood arteries, which can alter disease processes in target organs like the liver and pancreas, heart, or blood vessels, and may therefore significantly contribute to chronic inflammation like T2DM.[50]

Our study also showed that HOMA-IR was seen to be decreased with MCH in pre-diabetic patients. MCH showed an insignificant positive correlation with HOMA-IR (p= 019, r=0.83). The MCHC count was insignificantly higher in subjects with insulin resistance as compared to insulin sensitive groups among the pre-diabetics. On the other hand, other study also suggested that MCHC was insignificantly higher in male diabetics than pre-diabetics, there were no statistically significant difference in pre-diabetic and diabetic group in both genders. This needs further investigation, exact mechanism is not known to us.

Majorly four hematological parameters – WBC count, RBC count, hemoglobin, MCH were studied in our study. Hematological changes in diabetes can be caused by several factors including increased production of reactive oxygen species (ROS) and the formation of advanced glycation end products (AGEs) as a result of the long-term hyperglycaemia. The increase in WBC and RBC associated with IR may contribute to the increased cardiovascular mortality related to the metabolic syndrome. Several factors influence blood viscosity, including the quantity of white and red blood cells. Insulin's impact on erythropoiesis can cause blood viscosity to rise and circulatory dynamics to change. Blood viscosity has already been demonstrated to be a risk factor for stroke and myocardial infarction on its own.[51]

Metabolic syndrome has been believed to have numerous characteristics of an inflammatory disease. Several cytokines are involved (e.g. TNF-α, IL-6) were positively associated with IR and with the formation of the atherosclerotic plaque. In

addition, other inflammatory indicators, such as C-reactive protein, have lately been linked to cardiovascular disease and mortality.[51]

CONCLUSION

To conclude, this study explored different biochemical and hematological parameters for predicting an adverse outcome in pre-diabetic patients. It helped us in identifying few cost-effective conventional laboratory parameters such as insulin resistance and CBC which were found to be significantly associated with disease severity. Thus, using these routine tests at the time of admission can help in risk stratification and better management to timely identify the complications and improve the disease outcome. Thus, early identification of these parameters can help in monitoring the disease and predicting severity.

Limitation of the study

This is a hospital-based study, the need of hour is to carry out larger multicentre studies to establish the stronger association between hematological parameters and IR for better understanding of patho physiology of Type 2 DM and hence to discover early diagnosis and more effective treatment.

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