

## HbA1c AS A MARKER OF DIABETIC DYSLIPIDEMIA IN TYPE 2 DIABETIC PATIENTS: A CROSS SECTIONAL STUDY

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**ABSTRACT: BACKGROUND & OBJECTIVES:** Cardiovascular morbidity & mortality are predominantly seen in diabetic patients with dyslipidemia. But unfortunately, most of the diabetic patients are unaware of their dyslipidemic status. By diagnosing & initiating steps to normalize the levels of circulating lipids, the odds of developing cardiovascular complications and mortality can be decreased. Long term glycemic control can be monitored using glycosylated hemoglobin (HbA1c). **METHODS:** This study was carried out during the period from January 2011 to June 2012. A total of 167 patients (108 males & 59 females) with type 2 Diabetes Mellitus who satisfied the inclusion & exclusion criteria were included in the study. The sera of the selected subjects were analyzed for HbA1c, fasting blood sugar (FBS), postprandial blood sugar (PPBS), total cholesterol, triglycerides, high-density lipoprotein (HDL) and low-density lipoprotein (LDL) levels. **RESULTS:** A significant and direct correlation exists between HbA1c and serum levels of total cholesterol ( $r=0.524$ ), LDL ( $r=0.430$ ) and total triglyceride levels ( $r=0.620$ ) respectively. At the same time, this study also reveals a significant inverse relationship between HbA1c and HDL levels ( $r=-0.866$ ). **CONCLUSIONS:** The findings of this study illustrate the valuable additional information that can be provided about the levels of circulating lipids by testing HbA1c levels, apart from its primary role in monitoring long-term glycemic control. This study also emphasizes that persons with high levels of HbA1c should be evaluated for diabetic dyslipidemia and managed accordingly.

**KEYWORDS:** HbA1c marker, Diabetic dyslipidemia, Type 2 diabetes mellitus

**INTRODUCTION:** "By the end of this decade, every fifth Indian will be a diabetic and every fifth Diabetic in the world will be an Indian".<sup>1</sup>

Diabetes mellitus is the single most important metabolic disease recognized worldwide, as one of the leading causes of death and disability.<sup>2</sup> Type 2 diabetes mellitus is the commonest form of diabetes, constituting almost 90% of diabetic population. Prevalence of diabetes in the adults worldwide was estimated to be 4.0% in 1995 and expected to be 5.4% by the year 2025. Its incidence is higher in developing countries than developed countries.<sup>3</sup>

Today, India has the largest number of diabetic subjects when compared to any other country of the world. It has been estimated that presently 19.4 million individuals are affected by diabetes and these numbers are expected to increase to 57.2 million by the year 2025 which would be one-sixth of the total world population by then.<sup>4</sup> World Health Organization (WHO) has already declared India as the global capital of diabetes. In 1970s, the prevalence of diabetes among urban Indians was reported to be 2.1%, and this has now raised to 12.1%, a hefty 10% rise.<sup>5</sup>

Alarming, WHO has also revised the predicted number of diabetics in India to become nearly 80 million by 2030.<sup>6</sup>

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Type 2 diabetics have a higher risk of developing cardiovascular disease (CVD). In this subset of population, cardiovascular deaths represent the top killer.<sup>7</sup> Hyperglycemia is the apparent feature of diabetes due to diagnostic dependency of patients on blood glucose measurements. However, most of these individuals may also have undiagnosed dyslipidemia, characterized by increased levels of triglycerides and LDL and decreased HDL.

Diabetic patients, apart from enduring multiple complications of chronic hyperglycemia, tend to become soft targets of deadly cardiovascular disease (CVD). It has also been seen quantitatively that subjects with diabetes have greater than two-fold increased risk for cardiovascular death when compared to persons without diabetes.<sup>8,9</sup>

Glycosylated haemoglobin (HbA1c) levels are widely used as the standard biomarker for the adequacy of glycemic management. It has the ability to reflect the cumulative glycemic history of the preceding 2–3 months, hence an important indicator of long-term glycemic control. It plays a critical role in the management of the patient with diabetes, as it correlates well with both microvascular and, to a lesser extent, macrovascular complications. Recently, elevated HbA1c has been regarded as an independent risk factor for coronary heart disease (CHD),<sup>10</sup> and stroke,<sup>11</sup> in subjects with or without diabetes. It has been shown that improvement of HbA1c levels are seen even with attempts to reduce cardiovascular risk that too without any specific intervention targeted at improving glycemic control. Recent studies have shown the association existing between HbA1c and lipids.<sup>12,13</sup> Hence, this study was undertaken to examine the relationship between glycemic control and serum lipid profile and evaluate the relevance of HbA1c as an indicator of circulating lipids in male and female type 2 diabetic patients of Bijapur, Karnataka.

**MATERIALS AND METHODS:** This study was carried out in B.L.D.E.U's Shri B. M. Patil Medical College Hospital and Research Centre, which is a tertiary care multispecialty hospital & research centre at Bijapur, Karnataka. The study period was from January 2011 to June 2012. Patients presenting with type 2 diabetes mellitus with/ without dyslipidemia were included in the study. Following diabetic patients were excluded from the study:

- Patients who had a change in diet or diabetic treatment in last 6 weeks,
- Patients who were already on treatment for dyslipidemia,
- Patients with history of hemoglobinopathies (like sickle cell anemia) or having any other cause of hemolytic anemia,
- Patients with history of recent blood loss or history of recent blood donation/transfusion,
- Patients who presented in acute hyperglycemic or uremic states,
- Patients who were in a state of active erythropoiesis like in pregnancy,
- Patients who were taking aspirin, penicillin group of antibiotics, consuming alcohol on a regular basis.

Sample size was calculated using the statistical formula:

$$n = \frac{(1.96)^2 p(1-p)}{d^2}$$

Where, n = Sample size, p = prevalence rate and d = margin of error.

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With the prevalence rate of type 2 Diabetes mellitus taken as 12.4%,<sup>14</sup> confidence interval taken as 95% and allowing a 5% margin of error, the required sample size (n) was found to be 167 using the above statistical formula.

After obtaining the necessary approval and clearance from the institutional ethical committee, this prospective study was conducted upon the required sample representative of the population who had satisfied the inclusion and had presented to the hospital during the study period.

A detailed clinical history of each of the included subjects was taken and physical examination was done using a pre-approved standardized proforma. Following this, venous blood of each of the subject was drawn after ensuring that the subject had underwent at least 8 hours of overnight fasting.

The collected blood sample was sent to the central laboratory of the institution for testing the levels of fasting blood sugar (FBS), postprandial blood sugar (PPBS), HbA1c and lipid profile (Total cholesterol, total triglycerides, LDL and HDL). The reports of these investigations were collected. Later on, the entire collected data (Comprised of the details obtained from history taking, physical examination and the investigation reports) was meticulously compiled and analyzed using Predictive Analytics Software statistics' Statistical Package for Social Sciences (PASW-SPSS) version 18. Correlation was calculated using the formula of Pearson co-relation coefficient between HbA1c, FBS, PPBS and lipid profile. The obtained results were analyzed and inferences were drawn from these.

**OBSERVATIONS & RESULTS:** Table 1 gives an outline of the clinical profile of the patients involved in the study. The mean age of the study subjects was 57.03 years. The average duration of type 2 diabetes in the study subjects was approximately 5 years and 5 months. The mean blood pressure and pulse pressure of the subjects were 132.8/78.5 mmHg and 54.31 mmHg respectively. The average body mass index was 24.39 kg/m<sup>2</sup>. The mean FBS and PPBS levels of the study subjects were 147.5 and 223.8 mg/dl respectively. The average HbA1c level was 8.12%. With regards to the total cholesterol, LDL, HDL and total triglyceride levels, the mean values in the considered study subjects were, 176.9, 109.8, 32.27 & 176.1 mg/dl respectively. The mean ESR level was 18.1 mm/hour.

Table 2 shows age and gender-wise distribution of the study subjects. Out of the total 167 subjects, 108 were male and 59 were female. Majority of the study subjects were in the 51-60 year age group.

Table 3 shows the gender-wise distribution of the blood pressure among study subjects. Sixty percent of the normotensive study subjects (n=10) were female. Males were predominant in the pre-hypertensive group (65.8%) as well as in the isolated systolic hypertensive group (67.5%).

Gender-wise duration of diabetes has been displayed in figure 1. Out of the 167 study subjects, majority (n=134, M=87 and F= 47) had diabetes for 1-5 years and 10 subjects (M=5 and F=5) had diabetes for < 1 year, 6 subjects (M=3 and F=3) for 6-10 years, 4 subjects (M=3 and F=1) for 11-15 years and 13 subjects (M=10 and F=3) had it for >15 years.

Figure 2 gives an outline of the distribution of the subjects in accordance with the duration of diabetes and control of their BP. In patients with < 1 year of diabetes (n=10), it was noticed that only 1 patient was normotensive, 8 were in pre-hypertensive state and 1 had isolated systolic hypertension. In the group of patients having diabetes for a period of 1-5 years (n=134), 9 were normotensive, 102 were pre-hypertensive, and 23 had isolated systolic hypertension.

Out of the 6 subjects having diabetes of 6 to 10 years duration, 4 were pre-hypertensive and 2 had isolated systolic hypertension.

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In the group of patients having diabetes for a duration of 11-15 years (n=4), 1 was pre-hypertensive and the rest had isolated systolic hypertension. In the 13 subjects who had diabetes for a period of > 15 years, 2 were pre-hypertensive and the others had isolated systolic hypertension. None of the study subjects could be categorized into stage 1 or stage 2 hypertension.

The distribution of subjects according to body mass index and age has been shown in Table 4. Majority of the subjects were in the optimal weight category (53.9%). The next largest group of subjects belonged to the overweight category (41.3%). Only 5 study subjects had class 1 obesity. Overweight individuals were present in all the age groups.

Figure 3 shows the distribution of the study subjects, based on their BMI and blood pressure level. Majority of them (70%) were in the pre-hypertensive group irrespective of their BMI value. Only a meager percentage (6%) of the study subjects had a normal blood pressure. All subjects belonging to the obese class 1 category were found to be pre-hypertensive.

Table 5 shows the distribution of study subjects according to the duration of diabetes and their glycosylated hemoglobin level. It has been observed that irrespective of the duration of diabetes, most of the subjects had a high HbA1c level (n=74). This was followed by the subjects who had a fair control of diabetes as indicated by their HbA1c levels ranging from 7.1-8% (n=52).

### **Correlation between HbA1c and FBS, PPBS, Total Cholesterol, LDL, HDL, Total Triglycerides:**

The following scatter diagrams (Figure 4 to Figure 9) depict the correlation between HbA1c and the various main parameters of the study which included FBS, PPBS, total cholesterol, LDL, HDL and total triglycerides.

Pearson correlation coefficient ( $r$ ) was calculated to find out the correlation between the various variables and the scatter diagram was plotted.

The correlation between HbA1c and FBS (Figure 4) as well as between HbA1c and PPBS (Figure 5) was found to be positive. ( $r=0.579$  and  $r=0.602$  respectively). Similarly, a positive correlation was found between HbA1c and total cholesterol ( $r=0.524$ ), HbA1c and low density lipoproteins ( $r=0.430$ ) and between HbA1c and total triglycerides ( $r=0.620$ ) (Figures 6, 7 & 9 respectively). A negative correlation was found between HbA1c and high density lipoprotein ( $r=-0.866$ ) (Figure 8).

**DISCUSSION:** This study consisted of 167 subjects who were diagnosed earlier with type-2 diabetes mellitus and were already on treatment for their diabetes. But they were not diagnosed earlier with dyslipidemia and thus were not on any lipid lowering agents. The subjects who were included in the study were attending either the outpatient department, diabetic clinic or admitted as inpatient and had fulfilled the inclusion and exclusion criteria.

The significant correlation between HbA1c and FBS and PPBS (Figures 4 & 5) is in agreement with earlier studies.<sup>15-17</sup> A markedly increased risk of CHD events has been observed in both women and men with diabetes.<sup>18</sup> Even after successful reductions of LDL following statin therapy in diabetic patients, they continue to be at an increased risk of CHD if their HDL levels remain suboptimal.<sup>19</sup> However, susceptibility to CVD among type 2 diabetic patients differs markedly according to ethnicity and gender<sup>20</sup> though converse findings also exist.<sup>21</sup>

Significant correlations were observed between HbA1c and cholesterol, TG, HDL and LDL in diabetic patients (Figures 6 to 9) which is also in agreement with the findings of several other investigators who had reported significant correlations between HbA1c and lipid profiles and

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thereby suggested the importance of good management of diabetes by simultaneous control of dyslipidemia.<sup>13,16,22-24</sup>

As mentioned earlier, diabetic patients may turn out to be soft targets of cardiovascular diseases (CVD), apart from withstanding the other complications of chronic hyperglycemia. A major cause of reduction in life expectancy of such patients is also associated with cardiovascular complications.<sup>25,26</sup>

Ramachandran et al,<sup>9</sup> have reported synchronous occurrence of diabetes and cardiovascular events from the findings in a cohort of patients with acute coronary syndrome (without any prior glycemic checkup). This study showed that few patients (16.4%) had normal glucose tolerance and the remaining were either diabetic or had impaired glucose tolerance. Moreover, the role of hyperglycemia in CVD was supported by a direct correlation between fasting blood glucose (FBG) and cardiovascular events.<sup>27-28</sup> Even the presence of isolated postprandial hyperglycemia has been suggested to be a cardiovascular risk factor.<sup>29</sup> It has been noticed that glucose fluctuations (glucose swing) during postprandial periods exhibit a more specific triggering effect on oxidative stress than chronic hyperglycemia.<sup>30</sup>

It has also been noted that increased levels of maternal HbA1c could impair fetal long axis cardiac function,<sup>31</sup> which shows the impact of poor glycemic control whereas improving the glycemic control can substantially reduce the risk of cardiovascular events in diabetics.<sup>32,33</sup> An estimate suggested that by simple reduction of the HbA1c level by 0.2% could lower the mortality by 10%.<sup>34</sup>

Another study has found that improving glycemic control in patients with type 2 diabetes may be more important than treating dyslipidemia for the prevention of both microvascular and macrovascular complications.<sup>35</sup>

Although both FBG and HbA1c have been related to CHD in a similar way, the former association has been found to be much weaker.<sup>10</sup> A significant increase in total cholesterol, LDL and TGL levels as well as a decrease in HDL levels is exhibited by diabetic patients with poor glycemic control. A linear relationship between CHD and HbA1c in diabetic patients have been demonstrated by Selvin et al,<sup>10</sup> implying that the risk of CHD begins to increase even when the HbA1c level is below 7.0%. Grant et al,<sup>36</sup> have reported significantly higher CVD risk factors among individuals with HbA1c > 6.0%.

Interestingly, it has been shown that even attempts to reduce cardiovascular risks resulted in the improvement of HbA1c, even if no specific intervention was targeted at improving the glycemic control.<sup>37</sup> Studies have reported that HDL cholesterol is inversely associated and that non-HDL cholesterol is directly associated with CHD risk in diabetic patients.<sup>38</sup>

A study on female type 2 diabetic patients has revealed that association between non-HDL cholesterol and CHD risk is apparent in patients with elevated TGL.<sup>39</sup> Moreover, significantly high serum TGL levels have been found in diabetic patients with CHD as compared to non-diabetic patients.<sup>40</sup> Onat et al,<sup>41</sup> have suggested that fasting TGL levels are predictive for future CVD, independent of age, diabetes, total cholesterol and HDL.

The above discussion clearly indicates the clinical significance of various lipid parameters including total cholesterol, TGL, HDL and LDL in predisposing diabetic patients to cardiovascular complications. The significant correlation of HbA1c with all these lipid parameters (Figures 6 to 9) points towards the usefulness of HbA1c for screening high-risk diabetic patients.

**Limitations of the use of HbA1c as a marker.**

The limitations of the use of HbA1c as a marker for additional information on circulating lipids is that it cannot be used in the following Conditions:

1. Patients in acute hyperglycemic states.
2. Patients with uremia.
3. Patients taking aspirin and antibiotics from penicillin group.
4. Patients who consume alcohol regularly.
5. Patients with hemoglobin abnormalities like sickle cell anemia or having hemolytic anemia of any other etiology.
6. Patients with recent history of blood loss or of recent blood transfusion.
7. Patients in a state of active erythropoiesis, like in pregnancy.
8. Patients with already diagnosed dyslipidemia, undergoing treatment.

**CONCLUSION:** In conclusion, the findings of this study clearly show that HbA1c, in addition to its role as a reliable biomarker of glycemic control, can also be a good predictor of serum lipid profile in diabetic patients. In this study, HbA1c has showed direct and significant correlations with serum cholesterol, serum triglycerides and LDL levels. HbA1c has also showed an inverse correlation with serum HDL levels. The findings of this study illustrate the valuable additional information that can be provided by HbA1c about the levels of circulating lipids, besides its primary role in monitoring long-term glycemic control. The diabetic patients with HbA1c levels of > 8% tend to have moderate and severe dyslipidemia and therefore should be monitored thoroughly for their lipid profile and associated complications. Further studies in other regions of India are to be conducted to emphasize the role of HbA1c as a biomarker for screening of high-risk diabetic patients.

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<b>n = 167</b>	<b>Minimum</b>	<b>Maximum</b>	<b>Mean</b>	<b>Std. Deviation</b>
Age of Subjects (years)	36	86	57.03	9.586
Duration of Diabetes (months)	6	348	65.81	62.373
Systolic BP (mm/Hg )	88	230	132.85	14.693
Diastolic BP (mm/Hg )	50	110	78.54	8.818
Pulse Pressure (mm/Hg )	30	120	54.31	9.942



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Mean Arterial Pressure (mm/Hg)	62.6	150	96.64	10.091
Height (cm)	135	184	160.55	10.117
Weight (kg)	41	87	63.05	10.391
BMI (kg/m <sup>2</sup> )	16.29	33.26	24.392	2.884
FBS (mg/dl)	64	394	147.59	63.696
PPBS (mg/dl)	56	457	223.82	76.725
HbA1c (%)	5.00	14.80	8.126	1.736
<b>Total Cholesterol (mg/dl)</b>	<b>65</b>	<b>317</b>	<b>176.90</b>	<b>41.229</b>
LDL (mg/dl)	21	231.9	109.85	39.076
HDL (mg/dl)	17	43	32.27	4.449
<b>Total Triglycerides (mg/dl)</b>	<b>37</b>	<b>408.5</b>	<b>176.18</b>	<b>75.568</b>
E.S.R (mm/Hr)	5	140	18.10	17.684

Table 1

Age of the subjects	Gender		Total
	M	F	
<50 yrs of age	34	15	49
51-60 yrs of age	41	23	64
61-70 yrs of age	22	20	42
>70 yrs of age	11	1	12
<b>Total</b>	<b>108</b>	<b>59</b>	<b>167</b>

Table 2: Distribution of Subjects according to Age and Gender

BP	Gender		Total
	M	F	
Normal	4	6	10
Prehypertension	77	40	117
Isolated Systolic Hypertension	27	13	40
<b>Total</b>	<b>108</b>	<b>59</b>	<b>167</b>

Table 3: Distribution of Subjects according to BP and Gender

Body Mass Index	Age of Subjects				Total
	<50 yrs of age	51-60 yrs of age	61-70 yrs of age	>70 yrs of age	
Underweight (<18.5 kg/m <sup>2</sup> )	2	1	0	0	3
Optimal Weight (18.5-24.9 kg/m <sup>2</sup> )	20	36	23	11	90
Overweight (25-29.9 kg/m <sup>2</sup> )	25	24	19	1	69
Obese Class 1(30-34.9 kg/m <sup>2</sup> )	2	3	0	0	5
<b>Total</b>	<b>49</b>	<b>64</b>	<b>42</b>	<b>12</b>	<b>167</b>

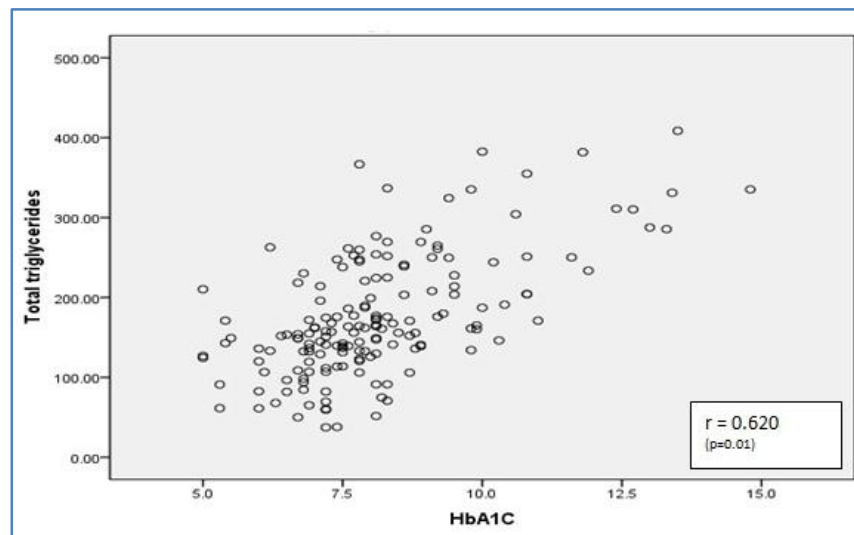
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Obese Class 1(30-34.9 kg/m <sup>2</sup> )	2	3	0	0	5

Table 4: Distribution of Subjects according to BMI and their Age

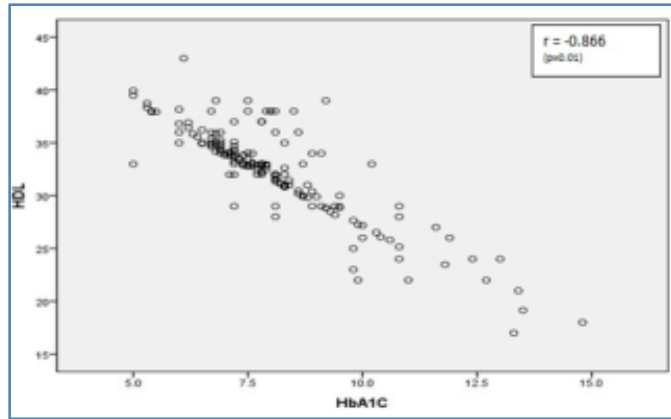
Duration of diabetes	HbA1c				Total
	Normal (4-6%)	Good Control (6.1-7%)	Fair Control (7.1-8%)	Poor Control (>8%)	
<1 yr	1	2	2	5	10
1-5 yrs	10	25	42	57	134
6-10 yrs	1	0	1	4	6
11-15 yrs	0	0	2	2	4
>15 yrs	0	2	5	6	13
<b>Total</b>	<b>12</b>	<b>29</b>	<b>52</b>	<b>74</b>	<b>167</b>

Table 5: Distribution of subjects in accordance with duration of diabetes and levels of HbA1c

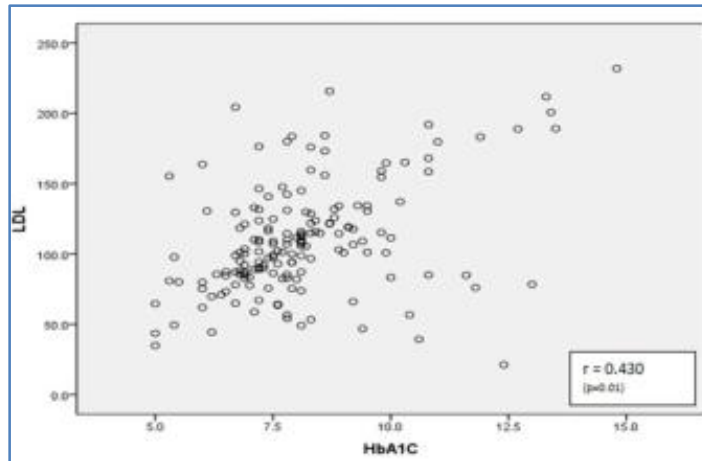


**Fig. 1: Bar chart showing the distribution of subjects according to duration of diabetes and their gender**

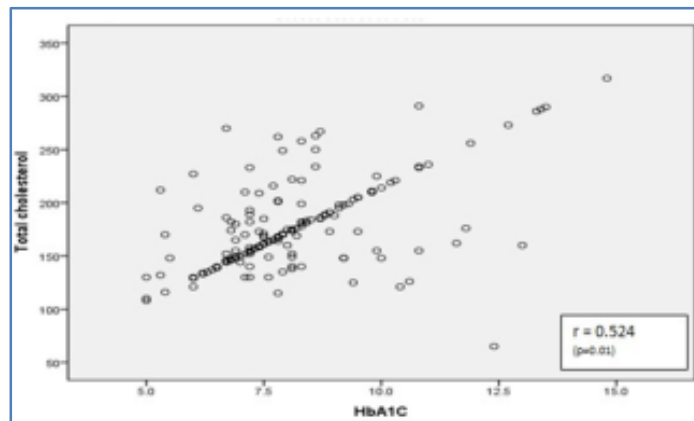
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**Fig. 2: Bar chart showing the distribution of subjects according to duration of diabetes and BP control**

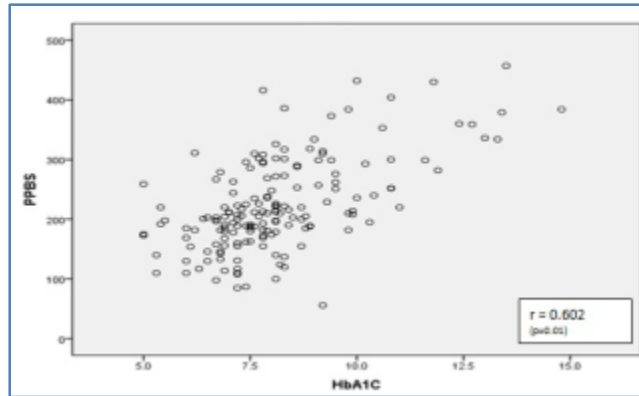


**Fig. 3: Bar chart showing the distribution of subjects according to BMI & BP**

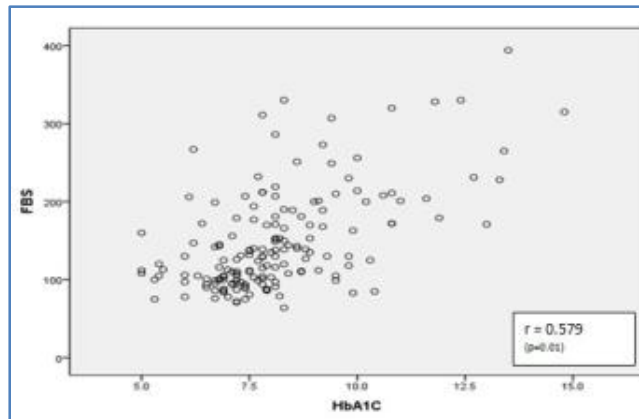


**Fig. 4: Scatter diagram showing the correlation between HbA1c and FBS levels**

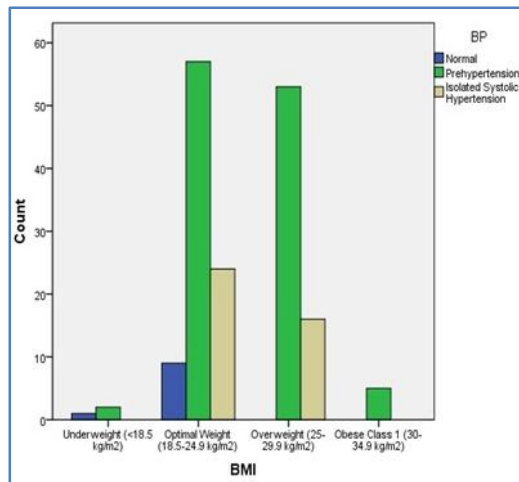
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**Fig. 5: Scatter diagram showing the correlation between HbA1c and PPBS levels**

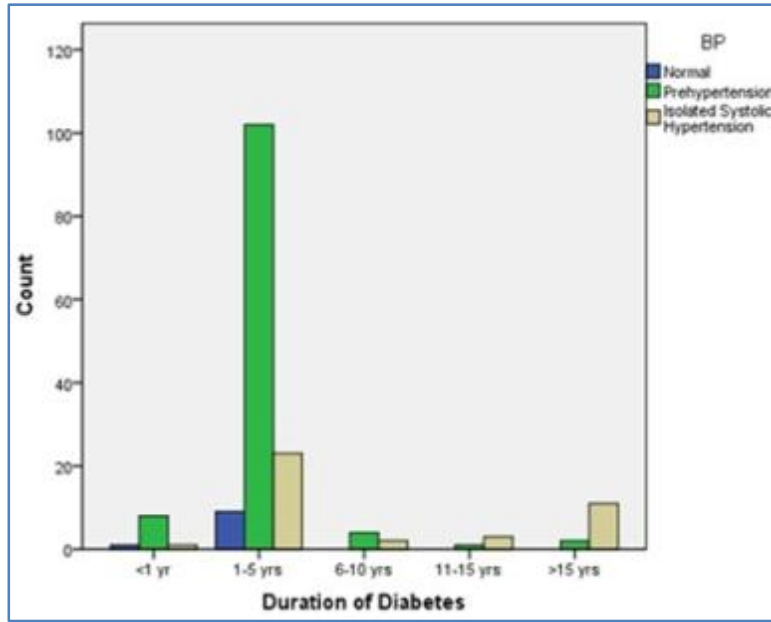


**Fig. 6: Scatter diagram showing the correlation between HbA1c and Total Cholesterol levels**

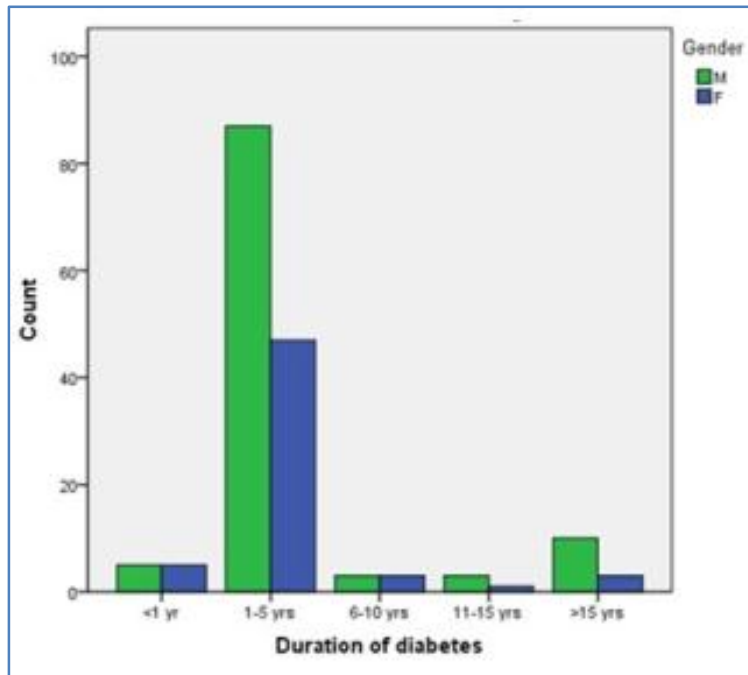


**Fig. 7: Scatter diagram showing the correlation between HbA1c and Total LDL levels**

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**Fig. 8: Scatter diagram showing the correlation between HbA1c and Total HDL levels**



**Fig. 9: Scatter diagram showing the correlation between HbA1c and Total Triglycerides levels**

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