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A study of comparison of fasting blood glucose level and postprandial blood glucose level v/s HbA1c level for long term control of diabetes: An observational study

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Abstract: Introduction: *Diabetes mellitus is a noncommunicable disease which is most prevalent and has become a modern epidemic. For many times, diabetes was diagnosed based on plasma glucose criteria, either the fasting blood sugar (FBS) or 2-h post prandial (PPG) in oral glucose tolerance test (OGTT). In 2009, an International Expert Committee recommended the use of glycated hemoglobin (HbA1c) to diagnose diabetes with a value of ≥6.5% and was accepted by ADA in 2010. Therefore the study was aimed to evaluate the predictive efficacy of glycated hemoglobin, fasting blood sugar and post prandial blood sugar as a diagnostic tool for diabetes mellitus and for long term control of diabetes mellitus.* ***Material and methods****: A hospital based cross sectional observational study of 200 case patients with type 2 diabetes mellitus were studied based on detailed history, examination, blood investigations, HbA1C.* ***Results****: suggests FBS and PP blood sugar contributed to overall glycemia but PP blood sugar glycemic contribution was relatively more than FBS levels.* ***Conclusion****: The result of our study showed that PPG strongly correlate with HbA1c or contributes significantly to overall glycemic control. Monitoring of PPG will be more helpful to achieve optimal glycemic control and prevent long term complication than FBS level.*

Keywords: *American diabetes association (ADA), Diabetes mellitus, fasting blood glucose, glycated hemoglobin, postprandial blood glucose.*

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I. Introduction

Diabetes mellitus is a noncommunicable disease which is most prevalent and has become a modern epidemic. [1] Globally, it is among the top ten leading causes of death in developed countries, and an epidemic in many developing countries. Diabetes mellitus have higher risk to develop both micro vascular and macro vascular complication. [2]

For many times, the diabetes was diagnosed based on plasma glucose criteria, either the fasting blood glucose (FBG) or a 2-h post prandial value in oral glucose tolerance test (OGTT). But the some limitations for the OGTT, fasting and 2-h postprandial plasma glucose, limit the clinical use of these methods. In 2009, an International Expert Committee which included representatives of the American Diabetes Association (ADA), the International Diabetes Federation and the European Association for the Study of Diabetes, this committee recommended the use of glycated hemoglobin (HbA1c) test to diagnose diabetes with a value of ≥6.5% and this criterion was accepted by ADA in 2010. [3] HbA1c test is convenient and easy to use and have low variability, greater stability and shows the average blood glucose level over the previous 8-12 weeks. [4-6]

Glycemic controls have an important role in management of diabetes to prevent acute and chronic complications of diabetes mellitus. Each 1% reduction of HbA1c was associated with decrease in risk of micro vascular complications in 37% cases and a 21% decrease in the end point disease risk or death related to diabetes mellitus . [7,8]

According to ADA, HbA1c levels in range of 5.7-6.4% are "at very high risk" for developing diabetes mellitus in 5 years. So that the range of 5.5-6.0% is the adequate cut off level for preventive measures.[3] Therefore the study was aimed to evaluate the predictive efficacy of glycated hemoglobin, fasting

blood sugar and post prandial blood sugar as a diagnostic tool for diabetes mellitus and for long term control of diabetes mellitus.

II. Aims And Objective

1. To study the comparison of fasting blood sugar and 2 hour post prandial blood sugar v/s HbA1c in known patients having Type 2 Diabetes Mellitus.
2. To find out which one of fasting and postprandial sugar is the dominant contributor to overall glycaemia in monitoring of diabetes.

III. Material And Methods

It is a Hospital based cross sectional observational study conducted during period of April 2017 to September 2018 in Mahatma Gandhi Medical College & Hospital, Jaipur. The patients of Type 2 Diabetes Mellitus attending Medical OPD and IPD of Mahatma Gandhi Medical College and Hospital, Sitapura, Jaipur were enrolled in the study. Written and inform consent was obtained from all participants before enrolment into the study and Institute Ethics Committee approval was obtained before start of study. This study was conducted from April 2017 to September 2018 and all the cases of Type 2 Diabetes Mellitus were included in study after considering inclusion and exclusion criteria. Data were collected by using Performa meeting the objectives of the study. Purpose of the study will be explained to the patients and consent was taken. All 200 case patients with type 2 diabetes mellitus after informed consent were studied based on the detailed history, anthropometric measurements, clinical examination, blood investigations and HbA1C. Statistical analysis was done by using SPSS statistical software (SPSS version 21). Patient demographics were reported as mean deviation and standard deviation for variables and percentages for categorical variables. Chi- square was used to compare category wise variables and to compare continuous variables among the two groups, independent sample test was used. Statistical significance was defined at a level of 5% ($p < 0.05$).

Inclusion criteria:

1. Old known cases of diabetes.
2. Newly diagnosed cases with RBS >200 mg%, FBS >126 mg%, PPBS >200mg%, HbA1c >6.5%
3. Patient willing with informed consent.

Exclusion Criteria

1. Unwilling patient excluded in the study
2. Chronic liver disease
3. Chronic kidney disease
4. Acute kidney disease
5. Hemolytic Anemia
6. Nutritional Anemia (Iron and vitamin B12 deficiency)
7. Hemoglobinopathies
8. Thalassemia
9. History of recent blood transfusion
10. Bone marrow suppression
11. Splenomegaly/splenectomy
12. Persons with mental illness
13. Gestational diabetes

IV. Observation And Results

Table 1: Distribution of patients on the basis of Gender

Gender	No. of cases (n)	Percentage (%)
Males	121	60.5
Females	79	39.5

Total 226 cases are enrolled in study but 26 cases did not reported for follow up. So, remaining 200 cases included in this study. In these 200 cases 79 were female and 121 were male (Table 1). SO, male female ratio for this study was 121:79. 60.5% males and 39.5% females were included in this study

Table 2: Distribution of patients on the basis of duration of disease

Duration of disease (years)	No. of cases (n)	Percentage (%)
< 3	76	38
3 - 5	56	28
>5	68	34

Out of 200 patients 76 cases had diabetes less than 3 years of duration,56 cases had diabetes 3-5years duration, 68 cases had diabetes >5 years of duration.(table 2).
we divided these cases in 2 subgroups according to goal level of HbA1c as per the American diabetic association, in to HbA1c ≤ 7 and HbA1c ≥7. Out of 200 patients 26 patients had HbA1c level ≤ 7 while 174 patients had HbA1c level >7 (Table 3).

Table 3: Distribution of patients on the basis of HbA1c levels

HbA1c (%)	No. of cases (n)	Percentage (%)
≤ 7	26	13
>7	174	87

Table 4: Comparison of Age in the study groups

Groups	No. of cases (n)	Age (years)	t-value	p-value
HbA1c ≤ 7 %	26	56.08± 11.43	0.210	0.834
HbA1c > 7 %	174	55.55± 12.09		

*Values presented as Mean± SD

Mean age for patients who had HbA1c levels ≤ 7 was 56.08± 11.43 years and HbA1c levels ≥7 was 55.55±12.09 years this difference was statistically no significant (p value=0.834). It shows both group were age matched. Table 4

Table 5.1: Comparison of Fasting Blood Glucose (I month) in the study groups

Groups	No. of cases (n)	Fasting Sugar (mg/dL)	t-value	p-value
HbA1c ≤ 7 %	26	131.88 ± 22.38	-4.485	<0.001
HbA1c ≥ 7 %	174	180.21 ± 54.16		

V. *Values presented as Mean± SD

Table 5.1 shows difference of mean levels of fasting blood sugar with comparison to level of HbA1c at starting of study. The level of mean Fasting Sugar was 131.88 ± 22.38 mg/dL in 26 patients whose HbA1c level was ≤ 7. While 180.21 ± 54.16 mg/dL for patients whose level was ≥ 7 %. This difference was statistically significant (p value <0.001).

Table5.2: Comparison of Fasting Blood Glucose (III month) in the study groups

Groups	No. of cases (n)	Fasting Sugar (mg/dL)	t-value	p-value
HbA1c ≤ 7 %	26	116.54 ± 23.63	-2.434	0.016
HbA1c > 7 %	174	131.01 ± 28.92		

*Values presented as Mean± SD

Table 5.2 shows difference of mean levels of fasting blood sugar with comparison to level of HbA1c after 3 months. The level of mean Fasting Sugar was 116.54 ± 23.63 mg/dL in 26 patients whose HbA1c level was ≤ 7. While 131.01 ± 28.92 mg/dL for patients whose level was ≥ 7 %.This difference was statistically significant (p value = 0.016).

Table 5.3: Correlation of HbA1c with Fasting sugar at I and III Month in Diabetic patients

	GROUP	Correlation coefficient (r)	P-value
I Month	**HbA1c vs Fasting sugar**	0.590	<0.001
III Month	**HbA1c vs Fasting sugar**	**0.625**	<0.001

*P-value as obtained on applying Pearson's correlation

Table 5.3 shows correlation between HbA1c levels and Fasting blood sugar at I month and III month. Both correlation was strongly positive and statistically significant (p<0.001).

Table 6 : Comparison of Blood glucose and HbA1c at I and III month in the study group

	I Month	III Month	t-value	p-value
Fasting Glucose (mg/dL)	173.93 ± 53.65	129.13 ± 28.62	13.234	<0.001
PP sugar (mg/dL)	232.68 ± 60.13	169.72 ± 33.80	**15.606**	<0.001
HbA1c (%)	9.18 ± 2.00	7.24 ± 1.25	**24.424**	<0.001

*Values presented as Mean± SD

Table 6 shows comparison between one and 3rd month levels of fasting, PP blood glucose and HbA1c levels. Difference between all three parameter was statistically significant (p value < 0.001)

Table7.1: Comparison of Post prandial Blood Glucose (I month) in the study groups

Groups	No. of cases (n)	PP Sugar (mg/dL)	t-value	p-value
HbA1c ≤ 7 %	26	184.81± 23.63	-4.563	<0.001
HbA1c > 7 %	174	239.83± 60.69		

*Values presented as Mean± SD

Table 7.1 shows difference of mean levels of postprandial blood sugar with comparison to level of HbA1c at starting of study. The level of mean PP Sugar was 184.81± 23.63 mg/dL in 26 patients whose HbA1c level was ≤ 7.While 239.83± 60.69mg/dL for patients whose level was ≥7 %. This difference was statistically significant (p value <0.001)

Table 7.2: Comparison of Post prandial Blood Glucose (III month) in the study groups

Groups	No. of cases (n)	PP Sugar (mg/dL)	t-value	p-value
HbA1c ≤ 7 %	26	155.00 ± 33.45	-2.407	0.017
HbA1c > 7 %	174	171.91 ± 33.40		

*Values presented as Mean± SD

Table 7.2 shows difference of mean levels of postprandial blood sugar with comparison to level of HbA1c after 3 months of starting of study. The level of mean PP Sugar was 155.00 ± 33.45 mg/dL in 26 patients whose HbA1c level was ≤ 7. While 171.91 ± 33.40 mg/dL for patients whose level was ≥ 7 %. This difference was statistically significant (p value <0.017).

Table 7.3: Correlation of HbA1c with PP sugar I and III Month in Diabetic patients

	GROUP	Correlation coefficient (r)	P-value
I Month	**HbA1c vs PP sugar**	0.609	<0.001
III Month	**HbA1c vs PP sugar**	0.675	<0.001

*P-value as obtained on applying Pearson's correlation

Table 7.3 shows correlation between HbA1c levels and Fasting blood sugar, HbA1c levels and PP sugar. Both correlation was strongly positive and statistically significant (p<0.001)

VI. Discussion

The present study titled "A study of comparison of fasting blood glucose level and postprandial blood glucose level v/s HbA1c level for long term control of diabetes: An observational study" was undertaken in the department of medicine of Mahatma Gandhi Medical College and Hospital, Jaipur (Rajasthan) from April 2017 to September 2018.

Type 2 diabetes mellitus (T2DM) is a noncommunicable disease which is a major public health problem. The micro vascular and macro vascular complications of DM are well known. T2DM remains the leading cause of end-stage renal disease, coronary artery disease, blindness, non-traumatic amputations, and hospitalizations. The knowledge of correlation of FPG and ABF with HbA1c may be helpful in the management of T2DM to achieve good glycemic control. The exact contributions of PPG and FPG to overall glycaemia remain controversial. There is limited evidence to suggest which one among the FPG and 2-hr ABF glucose is the dominant contributor to overall glycaemia in patients with T2DM.

Our study reveals that level of mean Fasting blood Sugar was 131.88 ± 22.38 mg/dL in patients whose HbA1c level was ≤ 7. While 180.21 ± 54.16 mg/dL for patients whose level was ≥ 7 %. This difference was statistically significant (p value <0.001) and after 3 month the level of mean Fasting Sugar was 116.54 ± 23.63 mg/dL in patients whose HbA1c level was ≤ 7. While 131.01 ± 28.92 mg/dL for patients whose level was ≥ 7 %. This difference was statistically significant (p value = 0.016).This result show significant (p value <0.001) positive correlation between fasting blood sugar and HbA1c levels.

Similar results were reported by Rohlfing et al[9] in 2002 which showed a strong positive correlation between HbA1c and FPG. Several studies revealed similar results like Liang et al[10] in 2010; Raja et al[11] in 2013; Lipska et al[12] in 2013; Kaur et al[13] in 2014 also showed strong positive correlation between HbA1c and fasting plasma sugar. A study conducted by emmanueal m. musenge et al[14] in 2016 showed positive but weak correlation between HbA1c and FPS. There was a statistically significant correlation but it shows weak positive correlation between HbA1c mean±SD (54.77±17.12 mmol/mol) and the previous FPG mean±SD (10.75±7.78 mmo/L) (r = 0.282, P = 0.001). However, there was a statistically significant moderately positive correlation in between HbA1c (54.77±17.12 mmol/mol) and the current FPG or after 3 month (11.09±6.23 mmo/L) (r = 0.385, P = 0.001). Another studies was conducted by Hossain et al[15] in 2012, Haddadinezhad & Ghazaleh et al[16] (2010) and Wiwanitkit et al[17] (2012), reported moderate correlations between HbA1c and FPG.

We found strong positive correlation between HbA1c and Fasting blood sugar levels. The possible explanation for that may be because the level of HbA1c is proportional to the level of glucose in the blood and

normal levels of glucose produce a normal amount of HbA1c. Thus, as the average amount of plasma glucose increases or decreases, the fraction of HbA1c increases or decreases in a predictable way and this serves as a marker for average blood glucose levels over the previous 2 to 3 months prior to the measurement. [18]

For PP blood sugar our study reveals that mean level of PP Sugar was 184.81± 23.63 mg/dL in patients whose HbA1c level was ≤ 7. While mean PP sugar level was 239.83± 60.69mg/dL for patients whose HbA1c level was ≥7 %. We found this difference statistically significant (p value <0.001) and mean level of HbA1c after 3 months was 155.00 ± 33.45 mg/dL in patients whose HbA1c level was ≤ 7, While it was 171.91 ± 33.40 mg/dL for patients whose level was ≥ 7 %. We found this difference was statistically significant also (p value <0.017). pearson correlation factor shows strong positive correlation between HbA1c levels and PP sugar which was statistically significant (p<0.001). Similar study by Avignon et al[19] in 1997 were the first to evaluate the relative value of plasma glucose at different time points during 24 hour in assessing long-term control in diabetic patients(type 2 diabetes). They found that pre breakfast, pre-lunch, pos tlunch and extended post lunch plasma glucose were all significantly correlated to HbA1c. In addition, post lunch and extended post lunch plasma glucose demonstrated better specificity and sensitivity and positive predictive value in predicting poor glycemic control (HbA1c = >8.5%)

Our study reveals significant positive correlation between HbA1c levels and fasting blood sugar at starting of study (r=0.590) (p value <0.001) and strong statistically significant correlation between HbA1c and PP blood sugar levels at same time or starting of study (r=0.609)(p value<0.001) and our study also reveals significant positive correlation between HbA1c levels and PP sugar after 3 months of study (r=0.625)(p value <0.001). We found strong statistically significant correlation between HbA1c and PP blood sugar levels at same time or after 3 months of starting of study (r=0.675) (p value<0.001). This shows strong positive correlation of HbA1c with both fasting blood sugar and PP blood sugar But we found this correlation is more strong with PP sugar in comparison to fasting blood sugar as correlation factor for HbA1c was more with PP blood sugar (r=0.609) & (r=0.675) than the correlation factor for fasting blood sugar(r=0.590) & (r=0.625) at starting of study and after 3 months of study respectively.

Our results are similar to study by Dr Swetha N K et al [20] in 2014 which show significant correlation (both between groups & within groups) between HbA1c & FBS, PPBS & RBS ('p'value-: <0.001) PPBS showed better sensitivity (79% vs. 74%) than Fasting glucose whereas Fasting glucose showed higher specificity (84% vs. 74%) and positive predictive value (87% vs. 80%) compared to post prandial blood glucose. Similar study conducted by Dr Swetha N K et al [20]in 2014 they divided study population into three groups based on their glycemic control, they found that there was significant increase in FBS, PPBS & RBS in group 2, &3 compared to group. There was significant correlation (both between groups & within groups) between HbA1c & FBS, PPBS & RBS ('p'value-: <0.001) PPBS showed better sensitivity (79% vs. 74%) than Fasting glucose whereas Fasting glucose showed higher specificity (84% vs. 74%) and positive predictive value (87% vs. 80%) compared to post prandial blood glucose. Another similar study was conducted by Shrestha L et al[21] in 2012 showed in their study both FBG and PPBG correlated significantly with HbA1c values. PPBG correlated more strongly with HbA1c in comparison with FBG.

These results suggests Fasting blood sugar and PP blood sugar contributed to overall glycemia contribution but PP blood sugar glycemic contribution was found relatively more than fasting blood glucose levels.

VII. Conclusion

HbA1c remains the gold standard in the assessment of glycemic control with availability of standardized methods. The limitation of resource or cost should not be the barrier to provide the good medical care. However in resource poor settings & in conditions with limitations for using HbA1c, FBS & PPBS can be used to monitor the glycemic control. The diabetic patients needs to be educated regarding the importance of achieving good glycemic control (To achieve Hba1c < 7%) so as to reduce the morbidity & mortality due to various complications of diabetes mellitus.

The result of our study showed that PPG strongly correlate with HbA1c or contributes significantly to overall glycemic control. This is in line with contemporary evidence that showed strong correlation between PPG and development of diabetes complications. Consequently we are in a position to claim that special attention should be given to monitoring and treating PPG until the ongoing debate are resolved through large randomized control trials. Hence monitoring of PPG will be more helpful to achieve optimal glycemic control and prevent long term diabetes complication than FPG alone in the absence of HbA1c.

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