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Correlation of Fasting and Postprandial Blood Glucose with Hba1c in monitoring Glycemic Control of Diabetic Patients in FCT Abuja, Nigeria

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ABSTRACT

Achieving glycemic control or reduction of hyperglycemia would significantly decrease most of the complications associated with hyperglycemia in diabetes mellitus. It has been stated that measurement of glycosylated hemoglobin (HbA1C) remains the gold standard for the assessment of glycemic control; there is no consensus whether the Fasting or Postprandial is a better predictor of glycemic control in poor resource setting where HbA1C is not easily accessed or available. The aim of this research is to determine fasting and postprandial plasma glucose and their correlation with HbA1C in glycemic control. A cross sectional case control study was carried out from January, 2023 to July, 2023; a total of 203 participants were recruited into the study. Fasting blood glucose (FBG), 2 hours post prandial blood glucose (2HPBG) were determined in all the subjects using the enzymatic glucose oxidase method for glucose estimation according to the instruction of the manufacturer, while HbA1C was determined using Boroaffinity Chromatographic method according to the instruction of the manufacturer. Statistical data analysis was carried out using SPSS software (Version 25.0, IBM Corp., Armonk, New York USA), and $p<0.001$ were defined as statistically significant; the correlation between the parameters was carried out using Pearson's correlation. Both the FBG and the 2HPBG showed positive correlation with HbA1C in the diabetic and control subjects; however, the level of correlation varies. The correlation of FBG and 2HPBG with HbA1C is directly proportional to the concentration of blood glucose level. The FBG for the control and the subjects are 7.40±1.59 and 143.67±5.01, with HbA1C of 4.45±0.05; 6.26±1.47 respectively. The 2HPBG for the control and the subjects are 120.70±1.75 and 192.92±7.05, with HbA1C of 5.56±0.07; 7.82±0.22 respectively. The FBG correlation to HbA1C is $r= 0.875$, $p<0.001$; while 2HPBG is $r= 0.908$,

p<0.001. The study showed positive correlation of FBG and 2HPBG with HbA1C, since HbA1C is the value of the percentage concentration of glucose at a given period of time; FBG, 2HPBG and HbA1C can be used to evaluate the degree of glycemic control in diabetic patients' management, in order to minimize or avoid diabetic complications.
Keywords: FBG, PBG, Diabetes, HbA1C, Correlation, Complications

INTRODUCTION

As a result of the pancreas' inability to produce enough insulin due to beta-cell loss in the islet of Langerhans [1], as seen in type 1 diabetes, or the body's cells not responding to the insulin produced as seen in type 2 diabetes [2], diabetes mellitus is a metabolic disease that causes high glucose levels in the extracellular fluid. Over the past forty years, the prevalence of diabetes has doubled. As a result of hyperglycemia, diabetes will be directly responsible for over 4 million deaths worldwide in 2020 [3], particularly due to cardiovascular diseases and kidney failure, both of which have a fatal effect on diabetics [4]. However, it is predicted that between 2020 and 2048, there will be an increase in diabetes cases worldwide of 48% [4]. Therefore, the reduction in morbidity and mortality among diabetic patients would greatly depend on how this disease condition is managed. High levels of glucose outside of cells may cause an increase in the glycosylation of common heme proteins like hemoglobin, resulting in the formation of glycosylated hemoglobin (HbA1C). However, the concentration of HbA1C predicts the development of diabetes complications because it indicates a higher level of harmful glycation complications from diabetes, such as retinopathy, neuropathy, and nephropathy, which are known to be caused by harmful advanced glycation end products [3]. The development and progression of eye, nerve, and kidney complications in diabetes type 1 and type 2 will decrease when HbA1C measurement is improved [5]. According to one study, when HbA1C 2 is reduced by just 1%, micro vascular complications are reduced by a total of 30-35 percent [6]. Additionally, a linear regression model found that the mean plasma glucose changed by 35 mg/dl (2 mmol/L) for every 1 percent change in HbA1C value. It was also discovered that macrovascular complications decreased by 14 to 16 percent for every 1 percent absolute decrease in HbA1C. Nevertheless, because HbA1C is insufficiently sensitive, it is not used for diagnosis [7-8]. Over the course of the red blood cell's 120 days or so of life, glycosylated hemoglobin has been shown to correlate with blood glucose levels [9]. The fundamental understanding that blood glucose levels determine HbA1C levels underpins the value of HbA1C as the current gold standard of clinical monitoring of diabetes [10]. Red cell survival may exhibit subtle differences between diabetes patients and non-diabetes patients, which could be taken into consideration. The average glucose level and the number of years that red blood cells remain in the body, however, are the two factors that affect the levels of glycosylated hemoglobin. Hemoglobin will have less time to become glycosylated and the amount of glycosylated hemoglobin will be lower if the red cell life expectancy is decreased due to another disease state, such as hemoglobinopathies [11-12]. There is no question that both fasting blood glucose and postprandial blood glucose (FBG and 2HPBG) contribute to HbA1C levels. As a result, predicting HbA1C using FBG and 2HPBG alone may be inaccurate. Clinically, some patients only achieve the FBG target or the 2HPBG target; however, it is currently unknown how to predict the HbA1C levels of each of these specific patients [13]. The relationship between blood glucose and HbA1C in glycemic control must therefore be considered when both FBG and 2HPBG are taken into consideration. This study seeks to ascertain the levels of FBG, 2HPBG, and HbA1C in diabetic subjects and assesses their correlation in order to determine their impact on glycemic control in Federal Capital Territory (FCT) Abuja, Nigeria.

MATERIALS AND METHODS

This cross-sectional case-control study was conducted between January 2023 and June 2023 to measure Fasting Blood Glucose (FBG), 2 Hour Postprandial Blood Glucose (2HPBG), and Glycosylated hemoglobin (HbA1C), as well as to assess the correlation between FBG and 2HPBG with HbA1C in diabetic and control patients attending the Diabetic Clinic in the General Hospital, Abuja, Nigeria. Each participant was given a thorough explanation of the study's goals and procedures before being asked to sign a consent form in their own handwriting as confirmation that they were willing to take part in the study. Following the subjects' consent to participate in the study, they were chosen at random. All of the patients ranged in age from 28 to 75 years, and subjects with underlying illnesses like sickle cell anemia or kidney disease were disqualified. 153 subjects who had been diagnosed as diabetic patients for five to seven years made up the study's study group, while 50 subjects who had never been diagnosed with diabetes made up the control group. A total of 203 subjects were recruited for the study.

Ethical Considerations

Ethical approval was obtained from the Research Ethics Committee of Bingham University, Karu Nassarawa State, Nigeria before the study was carried out and confidentiality assured to the subjects.

Informed Consents

Informed consents were obtained from all the subjects before commencement of the study.

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Data Collection

Prior to specimen collection, demographic information of the participants was obtained through administration of prepared questionnaires. Interpreter was provided for translation where it was necessary. Each questionnaire had a unique participant identification number (PIDN). The first part of the questionnaires contained the bio data of the patients e.g., sex, age etc. The second part consists of duration of the condition of diabetic condition. For reason of privacy, all data were kept confidential in accordance with World Medical Association declaration of Helsinki (WMA, 2013) [14]. For each participant, only the PIDN was recorded on the laboratory forms (no names). All the filled questionnaires were destroyed after data entry had been completed.

Biochemical Laboratory Investigations

All study participants were instructed a week before to come on an empty stomach for estimation of FBG, and after meal for 2HPBG and the sample forHbA1C was collected seven weeks after. Five milliliters of blood sample were drawn from each of the subject from the art cubical vein on their clinic visit days into Fluoride oxalate container by the medical laboratory Technician. After which, it was spin at 3000rpm for 5 minutes; the samples were analyzed using Glucose oxidase enzymatic method to determine the FBG and 2HPBG according to the manufacturer's instruction, following the standard procedures; while HbA1C was determine using Boroaffinity Chromatography assay method, according to the manufacturer's instruction and procedures. The Statistical data analysis was carried out using SPSS software (Version 25.0, IBM Corp., Armonk, New York USA), and $p<0.001$ were defined as statistically significant; while Pearson regression coefficient correlation was used for correlation. Ethical approval was sought and obtained from the Ethical clearance committee of Health Research Ethics Committee Bingham University with reference number BHU/FAHS/2023/01/97/21-01-23 dated January 21, 2023.

RESULTS

The Mean and Standard Deviation (SD) of Fasting blood glucose (FBG), 2-hour postprandial blood glucose (2HPBG) and HbA1C in the study subject and control group of participants are presented in Table 1. The comparison of mean of FBG, 2HPBG with HbA1C are presented as shown in Tables 2,3 and Figure 1; while the correlation of FBG and 2HPBG with HbA1C are presented in Tables 4, 5, 6 7 and Figures 2, 3, 4 and 5.

Tables 1 show Mean (χ) and Standard Deviation (SD) of FBG, HbA1C, PBG, HbA1C of Controls and Subjects.

Group	FBG (mg/dl)	HbA1C (%)	2HPBG (mg/dl)	HbA1C (%)
Control (n=50)	74.40 ± 1.59	4.45 ± 0.05	120.70 ± 1.75	5.56 ± 0.07
Subject (n= 153)	143.67 ± 5.01	6.26 ± 1.47	192.92 ± 7.05	7.82 ± 0.22
p-value	< 0.001	< 0.001	< 0.001	< 0.001

Values are mean ± SD, n= number of Sample; FBG= Fasting Blood Glucose, PBG= Post prandial Blood Glucose, HbA1C= Glycated Hemoglobin, P-value ≤ 0.05 is Statistically Significant.

The comparison of Mean and Standard Deviation (SD) of FBG and HbA1C is presented in table 2.

Table 2 shows Comparison of Mean (χ) and Standard Deviation (SD) of FBG, HbA1C, of Controls and Subjects

Parameter	Control (n=50)	Subject (n= 153)	p-value	Remark
FBG (mg/dl)	74.40 ± 1.59	143.67 ± 5.01	< 0.001	SS
HbA1C (%)	4.45 ± 0.05	6.26 ± 1.47	< 0.001	SS

Values are mean ± SD, n= number of Subjects; FBG= Fasting Blood Glucose, HbA1C= Glycosylated Hemoglobin, SS = Statistically Significant, P-value ≤ 0.05 is Statistically Significant.

The comparisons of Mean and Standard Deviation (SD) of 2HPBG and HbA1C in the control and study groups are presented in Table 3.

Table 3 shows Comparison of Mean (χ) and Standard Deviation (SD) of 2HPBG, HbA1C of Controls and Subjects

Parameter	Control (n=50)	Subject (n= 153)	p-value	Remark
2HPBG (mg/dl)	120.70 ± 1.75	192.92 ± 7.05	< 0.001	SS
HbA1C (%)	5.56 ± 0.07	7.82 ± 0.22	< 0.001	SS

Values are mean ± SD, n= number of Subjects; PBG= Post prandial Blood Glucose, HbA1C= Glycosylated hemoglobin, SS = Statistically Significant, P-value ≤ 0.05 is Statistically Significant.

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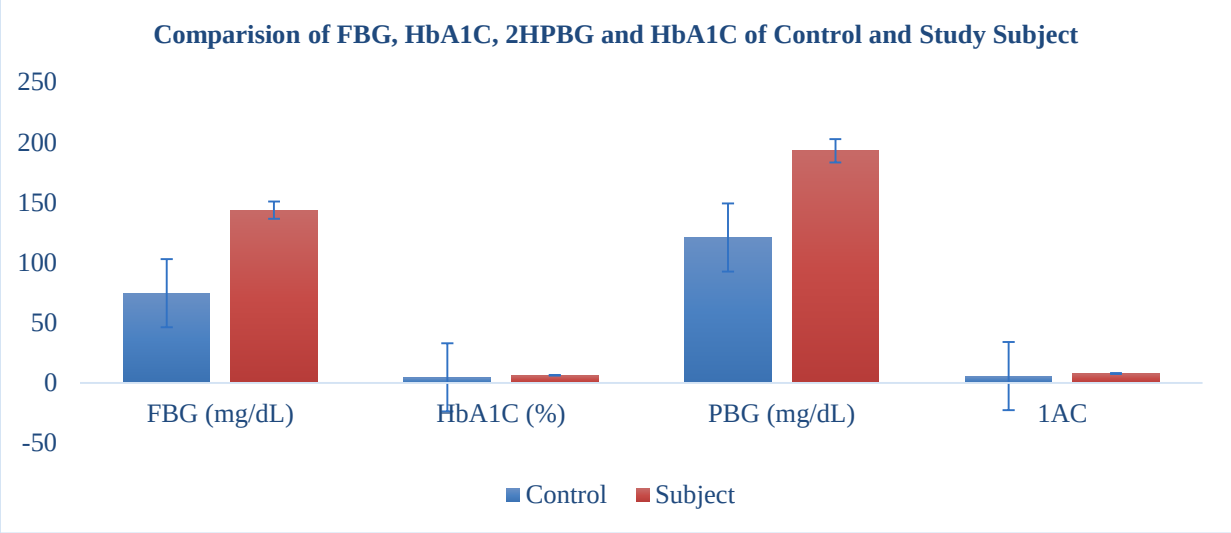

Fig. 1: Shows Comparison of Means for FBG and its HbA1C; 2HPBG and its HbA1C of Controls and Study Subjects.

The Pearson Correlation coefficient of FBG and HbA1C of control group are presented as shown in Table 4.

Table 4 show Pearson Correlation of FBG and HbA1C of Control Group

Parameter	Coefficient of Correlation (r)	P-value
FBG/HbA1C	0.875	<0.001

Correlation is significant at the p< 0.01 level

The Pearson Correlation coefficient of 2HPBG and HbA1C of control group are presented in Table 5.

Table 5 show Pearson Correlation of 2HPBG and HbA1C of Control Group

Parameter	Coefficient of Correlation (r)	P-value
2HPBG/HbA1C	0.908	<0.001

Correlation is significant at the p< 0.01 level.

The Pearson Correlation of FBG and HbA1C of Diabetic (Study subject) are represented as shown in Table 6.

Table 6 show Pearson Correlation of FBG and HbA1C of Diabetic (Study Subject)

Parameter	Coefficient of Correlation (r)	P-value
FBG/HbA1C	0.985	<0.001

Correlation is significant at the p< 0.01 level.

The Pearson Correlation of 2HPBG and HbA1C of Diabetic (Study Subject) are represented as shown in Table 7.

Table 7 show Pearson Correlation of 2HPBG and HbA1C of Diabetic (Study Subject)

Parameter	Coefficient of Correlation (r)	P-value
2HPBG/HbA1C	0.990	<0.001

Correlation is significant at the p< 0.01 level.

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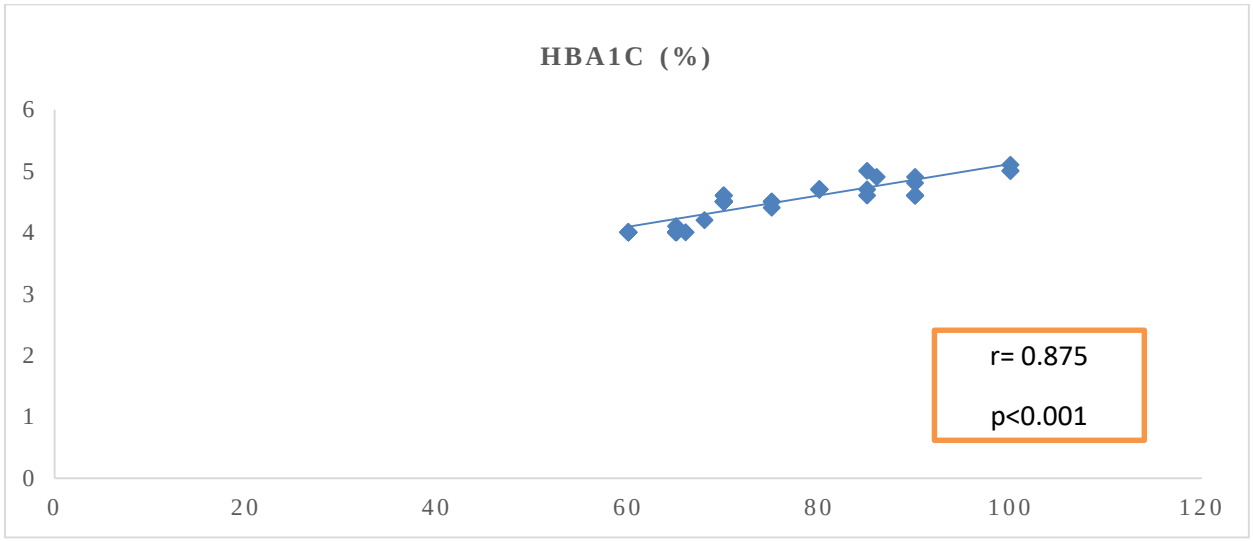

Figure 2. Scatter graph of FBG of Control Group against HbA1C (r=0.875, p<0.001).

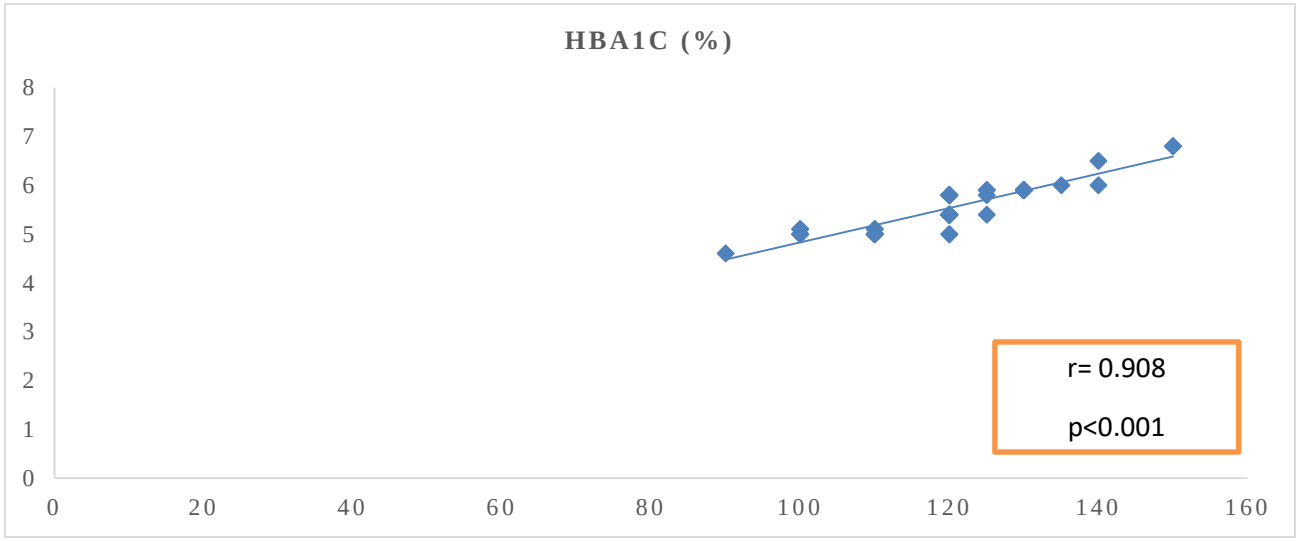

Figure 3. Scatter graph of 2HPBG of Control Group against HbA1C (r=0.908, p<0.001).

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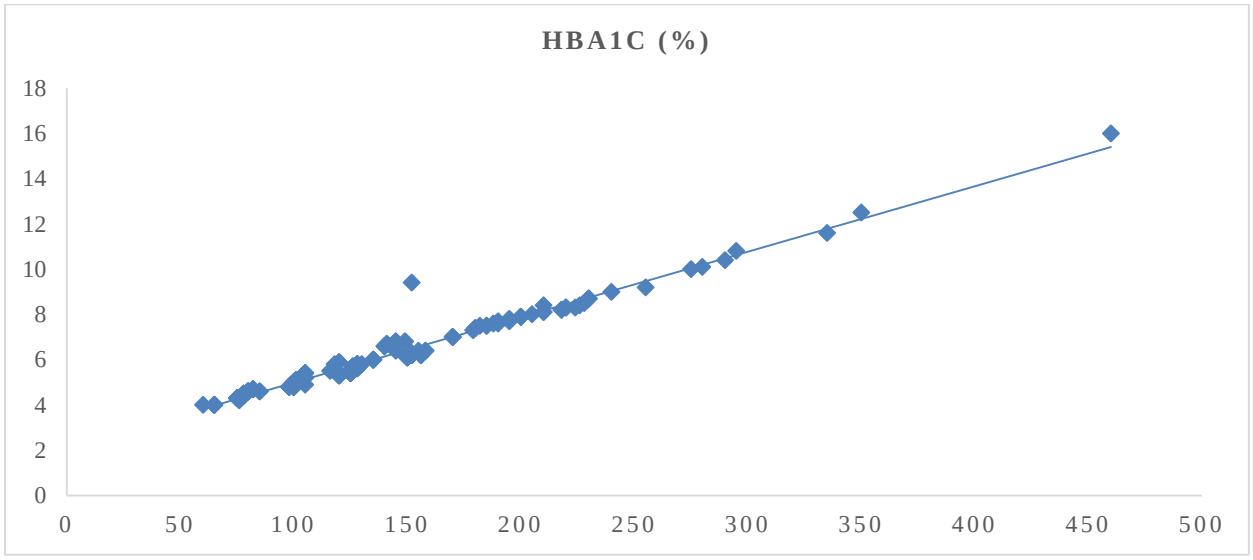

Figure4. Scatter graph of FBG of Study Subject against HbA1C (r=0.985, p<0.001).

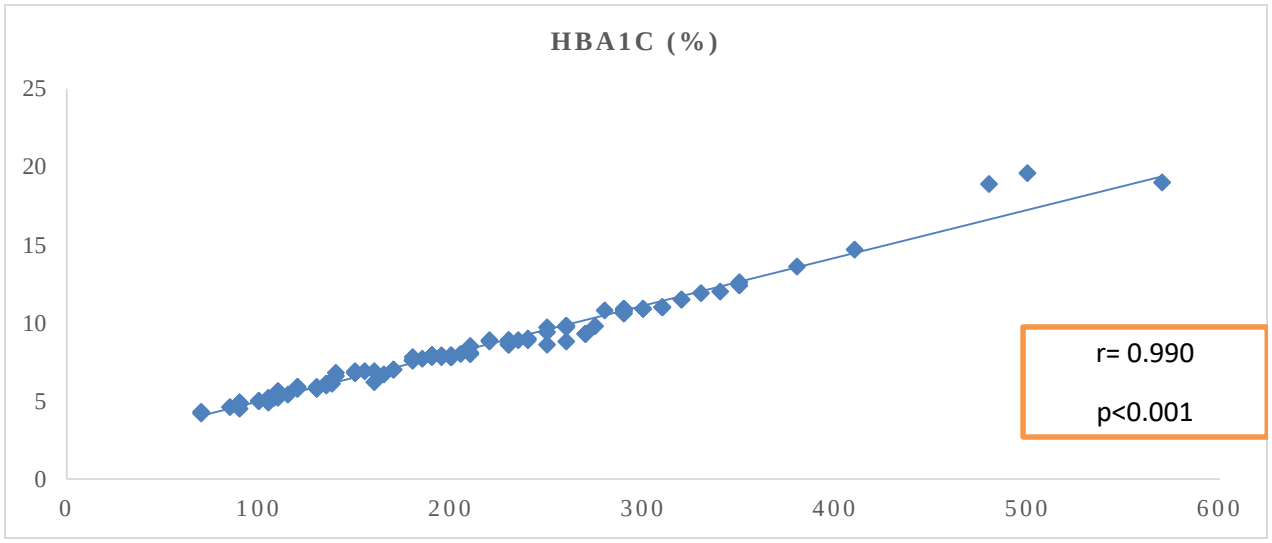

Figure5. Scatter graph of 2H PBG of Study Subject against HbA1C (r=0.990, p<0.001).

DISCUSSION

Diabetes mellitus is a chronic disease that affects a large portion of the population worldwide, both in developed and developing nations. A recent study reveals that non-communicable disease incidences have surpassed communicable disease incidences even in developing countries. Previously, it was believed that this non-communicable disease primarily affected the western population. Diabetes mellitus is a chronic condition that needs lifelong care and dietary changes modifications that improve the patient's quality of life by preventing the occurrence of acute complications and lowering the risk of long-term microvascular and macrovascular complications. Maintaining better glycemic control can help prevent the disease's complications to a large extent. This emphasizes the requirement for development.

Effective assessment techniques for keeping track of blood sugar levels include fasting blood glucose (FBG), two hours postprandial blood glucose (2HPBG), and glycated hemoglobin (HbA1C), according to [14]. The determination of HbA1C can be used for patient follow-up even though a case of diabetes is diagnosed with FBG, 2HPBG, and HbA1C values [4, 13]. High glycation of hemoglobin caused by hyperglycemia increases the risk of complications for the kidneys, retina, and neurons. In diabetic patients, proper hyperglycemia management can reduce the risk of

complications from the disease. The most effective method to stop or slow the development of diabetes complications and enhance quality of life is proper glycemic control [15-16].

According to the findings of this study, there was a strong correlation between PPBG and FBG. HbA1C results. Compared to FBG, 2HPBG and HbA1C showed a stronger correlation. This outcome supports the finding by Stratton (6) and Rosediani [7] that 2HPBG correlate much better than FBG. However, research conducted by other researchers has found that postprandial blood glucose and FBG have a stronger correlation with HbA1C [16-18]. Although he never specified the condition of the glucose analyzed, Bonora et al concluded that there are no significant correlations between blood glucose levels and HbA1C. As a result, due to the wide range of findings from different researchers in this field, the interpretation of the correlation between FBG and 2HPBG with HbA1C must be done with considerable cushion. The diagnosis of diabetes can be made using FBG, 2HPBG, and HbA1C values; however, in the evaluation of diabetic patients, HbA1C should be used as a follow-up of the patients to ascertain their glycemic control. Given that red blood cells only live for three months, glycated hemoglobin, which is produced when blood glucose concentrations are high, serves as a blood glucose level indicator over a three-month period. Therefore, in diabetic patients with high HbA1C, the accumulation of glycated end products in cells and tissues will result in macro and micro vascular complications [12-14]. Since higher values of HbA1C predispose patients to complications, it can be used as a predictor of diabetic complications. Since HbA1C does not accurately reflect blood glucose levels, particularly in conditions that affect hemoglobin structure and function, it is not used as a diagnostic test for diabetes. This is the primary reason why HbA1C is less trustworthy than FBG and 2HPBG [19]. In this study, it was found that the levels of HbA1C in diabetic subjects are directly correlated with blood glucose levels. As a result, if the blood glucose level is high, the HbA1C percentage value will also be high. Glycemic control can also be checked or monitored by estimating both FBG and 2HPBG. This ought to be advocated for low-income resource communities, as they might not have access to or the financial means to pay for HbA1C due to its high price [2024]. The study's sample size was average, and the number of participants with good or poor glycemic control was not quantified. As a result, we recommend taking a larger sample size. This will allow other researchers to investigate the validity of using HbA1C as a tool to monitor hyperglycemia and glycemic control in diabetic patients [25-28].

CONCLUSION

This study has shown that FBG and 2HPBG correlate well with HbA1C, and as such HbA1C can be used to evaluate the glycemic control of diabetic patients; nevertheless, the evaluation of HbA1C in diabetic condition must be done with cushion bearing in mind the state of the red cells and its life span. However, due to the high cost of HbA1C determination, FBG or 2PBG could be used to evaluate glycemic control in diabetic condition in low resources countries.

AUTHORS CONTRIBUTION

ASP: The principal investigator: responsible for research concept and selection of research title, wrote the research protocol and proposal; analyzed and collated the research data; also involved in carrying out the statistical analysis of the data along with the other authors, documented and interpreted the data; wrote the manuscript.

S M G: Responsible for collation of data and involved in statistical analysis

C E: Involved in the sample processing and data collation.

E I O: Involved in the selection of the research title and supervision of the research work and involved in statistical analysis of data.

C J: Involved in data collation and documentation.

All the authors read and approved the manuscript for publication

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Conflict of interest: The authors declare that no conflicts of interest exist.

Availability of data: The data will be available from the corresponding author on necessary request.

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