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THE RELATIONSHIP BETWEEN PATIENT CHARACTERISTICS AND GLYCEMIC CONTROL (HbA1c) IN TYPE 2 DIABETES PATIENTS ATTENDING THIKA LEVEL FIVE HOSPITAL, KENYA

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ABSTRACT

Type 2 Diabetes Mellitus is a metabolic disorder characterized by hyperglycemia due to relative insulin secretion deficiency and insulin resistance. It is a global public health concern with increasing prevalence each year. Social demographic, lifestyle and metabolic characteristic, play a crucial role in development and progression of Type 2 diabetes mellitus. Poor glycemic control worsens the condition, leading to complications that are very costly to treat. This calls for a need to explore the relationship between patient characteristics and glycemic control (HbA1c). One hundred and fifty three (153) participants with Type 2 diabetes mellitus aged 20-79 years and attending the Thika Level Five Hospital were enrolled in the study. Socio-demographic, clinical and lifestyle data were obtained using questionnaires. The nutrition status was determined by anthropometry. Lipid profile that included total cholesterol, (TC); high density lipoprotein-cholesterol, (HDL-c); low density lipoprotein cholesterol, (LDL-c) and triglyceride, (TG,) were determined by enzymatic method while glycated hemoglobin (HbA1c) and fasting blood sugar (FBS) were determined using high-performance liquid chromatography (HPLC) and glucose oxidase methods, respectively. Blood pressure of the patients was also determined. Overall sample size was 153 (40.5% men and 59.5% women). The overall mean age of patients was 56.07 years, and the mean age of patients with poor glycemic control (HbA1c>7%) was 56.79 years. The prevalence of the poor glycemic control (HbA1c>7%) was 77.8%. Participants with HbA1c > 7% showed statistically significant higher means for FBG, TC, and LDL-c than their counterparts with good glycemic control [11.71±3.11mmol/l vs. 8.54±3.19; 5.11±1.21mmol/l vs. 4.48±1.16 and 2.66±1.07 mmol/l vs. 2.22±1.04, respectively, ($P<0.005$; 0.000, 0.008 and 0.034, respectively]. The study showed a significant strong positive correlation between HbA1c and FBG ($r=0.679$, $p<0.01$); family history of diabetes, (FHD) ($r=0.165$, $p<0.05$); systolic blood pressure, (SBP) moderated with FHD ($r=0.168$, $p<0.05$); and diastolic blood pressure (DBP) moderated with FHD($r=0.181$, $p<0.05$). In conclusion, poor glycemic control is associated with high/ blood pressure, high blood glucose and dyslipidemia, which are risk factors for macrovascular, microvascular and cardiovascular complications.

Key words: Type 2 Diabetes Mellitus, glycemic control, cardiovascular risk, Patient characteristics

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INTRODUCTION

Type 2 diabetes mellitus is a heterogeneous disorder characterized by hyperglycemia due to relative insulin insufficiency and impaired effectiveness of insulin action[1]. It is a global public health problem and life threatening condition with increasing prevalence each year [2,3]. It is estimated that about 424.9 million (8.8%) adults worldwide aged between 20-79 years had Type 2 diabetes mellitus in 2017 with 4.0 million deaths [3]. This prevalence is projected to increase to 628.6 million (9.9%) by the year 2045, if no interventions are put in place [3]. The problem is especially worse in the West Pacific region (158.8 million) followed by South East Asia (82 million) with Africa registering a prevalence of 15.9 million and a projection of 40.7 million by 2045 [3]. In Kenya it is estimated that 458,900 (2.0%) people had Type 2 diabetes mellitus by 2017 [3] . However, this prevalence might be higher due to high rate of undiagnosed diabetes [3].

Type 2 diabetes mellitus is the fourth leading cause of death in most developed countries and studies also indicate that it is an epidemic in many developing countries including Kenya [2,3]. It is the main cause of morbidity in developed countries, with a fast growing incidence due to demographic transition and changes in the population's lifestyle [2,3].Traditionally, it was mainly diagnosed in people aged 20 years or older [3]. Increasingly, however, it is being diagnosed in younger patients as well, as a consequence of the growing incidence of childhood obesity [3].

Type 2 diabetes mellitus is defined by fasting plasma glucose of ≥ 7mmol/L, taken after at least 8 hours of no caloric intake; or by a 2 hour plasma glucose value (2 h PG) of ≥ 11.1 mmol/L, after administration of a glucose load containing an equivalent of 75g of anhydrous glucose dissolved in water, as per a method referred to as the oral glucose tolerance test (OGTT). For patients with classic symptoms of hyperglycaemia a random plasma glucose of ≥ 11.1mmol/l is diagnostic [1].Type 2 diabetes mellitus is considered a chronic metabolic disorder characterized by a rise in blood glucose level and glycated hemoglobin (HbA1c) of above 7% [1].

Type 2 diabetes mellitus results from the interaction of genetic, metabolic and environmental factors, among which lifestyle has an important role in its development [4]. Social, economic, and lifestyle factors are associated with the development and progression of Type 2 diabetes mellitus [4,5]. Income, education, employment, housing, access to nutritious food, family and social support are some of the social and economic determinants to health which are central to the development of Type 2 diabetes mellitus [4–6]. All these have also been shown to influence health behavior like adherence to medication and lifestyle choices which are fundamental to management of Type 2 diabetes [6]. Glycated hemoglobin A (HbA1c) is a hemoglobin variant that is formed when glucose binds covalently to the beta-chain of hemoglobin A (HbA) which is characterized by formation of initial shift base that is subsequently arranged to a stable Amadori product, produced in the early stage of advanced glycation end products (AGEs) formation. The formation of AGEs plays an important role in the development and progression of the long term complications of Type 2 diabetes mellitus [1]. Therefore, determination of HbA1c is key in management of

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patients with Type 2 diabetes mellitus as it helps in the monitoring of long-term glycemic status (2-3months), evaluating the adequacy of diabetes management in addition to adjusting therapies [1].Glycated Hemoglobin(HbA1c) has been accepted the world over as a reliable indicator in assessing chronic glycemia in Type 2 diabetes mellitus patients and its importance in the management of Type 2 Diabetes mellitus is well established [1,2].

Preventing Type 2 Diabetes mellitus and its complications is a priority in global public health [2,3].Moreover, knowing the relationship between patient characteristics and HbA1c is important in Type 2 diabetes mellitus prevention at different levels. Indeed, this would act as one of the key elements to support a preventive programme aimed at ensuring good glycemic control as well as reducing Type 2 diabetes mellitus related complications. Therefore, the present research aimed at exploring the relationship between patient characteristics and HbA1c in Type 2 Diabetes mellitus patients attending level 5 Hospitals in Kenya. The results will help in developing strategies aimed at preventing Type 2 Diabetes and its complications.

METHODOLOGY

This study employed a cross sectional design to determine the relationship between patient characteristics and HbA1c. It was a hospital-based study conducted on Type 2 diabetes Mellitus patients aged 20-79 years who were attending Thika Level 5 Hospital Diabetes Comprehensive Care Centre (DCC). Type 2 diabetes mellitus patients with complications like renal failure, congestive heart failure (CCF), and stroke were excluded from the study during recruitment.

The demographic data were obtained using structured questionnaires. Anthropometric measurements which included weight, height, waist and hip circumferences were taken using standard methods [7,8]. Body Mass Index (BMI) was calculated as weight (kilograms)/height (meters^2) and classified as per WHO classification [9]. Systolic and diastolic blood pressure was measured by trained nurses on the left arm with a Spengler digital sphygmomanometer (model: Autortensio® noSPG440), while the subjects were in a seated position with the arm supported at heart level and recorded in mmHg. Level of serum triglycerides (TG) was determined using Glycerol Phosphate Oxidase Peroxidase GPO/POD, endpoint method [10] , total cholesterol (TC) using Cholesterol Oxidase Peroxidase (CHOD-POD), end point method [11] and high density lipoprotein (HDL-c) using Phosphotungstic Acid, end Point method [12]). Serum low density lipoprotein cholesterol (LDL-C) was calculated using the Friedwald's formula (LDL-cholesterol (mmol/l) = Total cholesterol - (HDL+ triglycerides/2.181) [13].Glycated hemoglobin (HbA1c) was determined by Biorad D-10 hemoglobin testing system an automated analyzer, intended for percent determination of HbA1c in human blood using high-performance liquid chromatography [14] and fasting blood glucose (FBG) was determined by glucose oxidase method [15].

Classification of biochemical parameters

Glycemic status was categorized as: good glycemic control (HbA1c <7%) and poor control (HbA1c >7%) as per the American Diabetes Association guidelines (ADA) [1].

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Elevated blood pressure was considered for participants with systolic/diastolic pressure of 130/80 mmHg or those already using hypertensive drugs [16]. Classification of lipid profiles was done as described by the ADA [1] and American Association of Clinical Endocrinologists and American College Of Endocrinology (AACE-ACE) [17]. These include elevated triglycerides (≥1.7 mmol/l and/or the use of triglyceride-lowering drugs), reduced HDL cholesterol (<1.0 mmo/l in males and <1.3 mmol/l in female(s), elevated LDL cholesterol (>2.6mmol/l) and elevated total cholesterol(>5.2mmol/l) [1,17].

Classification of anthropometric parameters

High waist circumference was considered if the participant had waist circumference ≥94 cm in males and ≥80 cm in females [18] and BMI was categorized as obese >30kg/m^2 and non-obese <30kg/m^2 [9].

Sample size determination

A minimum sample size of 139 was determined using the formula by Armitage *et al.* [19] and Lwanga & Lemeshow [20]. The sample size was subjected to a correction factor of 10% to cater for attrition, hence, a total sample size of 153 was used.

Data analysis

Data analysis was performed using Microsoft windows SPSS version 20. Data were expressed as mean ± standard deviation for continuous variables or proportion and percentages for categorical variables. Categorical variables were compared using Chi-Square test or fisher exacts test. Independent-t- test was used to determine statistical differences between groups. The relationship between patient characteristic and HbA1c was first determined using Pearson bivariate correlation for continuous variables and Point biserial correlation for categorical variables. Bivariate regression analysis was performed to determine patient characteristics (social demographic, medical history, lifestyle and metabolic risk factors) associated with poor glycemic control (HbA1c >7%) in patients with Type 2 diabetes mellitus. An odds ratio with a P-value of <0.05 was considered statistically significant. Multivariate linear regression analysis was performed to evaluate whether the prediction of the metabolic risk factors alone and with an interaction term (family history of diabetes; FHD) contributed to the risk of poor glycemic control. A standardized regression coefficient (β) with p<0.05 was considered significant.

RESULTS AND DISCUSSION

Type 2 Diabetes Mellitus is a major metabolic disorder of global public health concern due to its increasing prevalence as well as related complications associated with poor glycemic control [3]. The glycemic control can be described by either the amount of HbA1c or FBG levels [1]. In the current study, HbA1c as defined by ADA has been used to describe glycemic control [1]. Glycated hemoglobin (HbA1c) of <7% is recommended for Type 2 diabetes mellitus patients since higher levels (HbA1c>7%) are associated with increased risk to microvascular and macrovascular complications. Good glycemic control (HbA1c<7%) is one of the best strategies to prevent and delay the progression of Type 2 diabetes mellitus complications [1]. Prevention of

complications caused by Type 2 diabetes mellitus leads to improved quality of life [1]. The current study showed a high prevalence (77.8%) of inadequate glycemic control (HbA1c>7%) as well as a high mean (8.5%) above the recommended level of HbA1c<7% in Type 2 diabetes mellitus patients studied. The findings of the study are in agreement with other studies conducted in Type 2 diabetes mellitus patients that showed higher mean of HbA1c above 8% as well as high prevalence's of > 60% of poor glycemic control (HbA1c>7%) [21,22].

Additionally, as shown in Table 1, there was a statistically significant difference in mean HbA1c between patient with a family history of diabetes (8.16±1.62%, p=0.04) compared to those without (8.77±2.00%). Moreover, there was statistically significant difference in mean HbA1c between patients aged >50 years (8.70 ± 1.03, p=0.04) compared to those < 50 years. Age has been shown to be a risk factor in Type 2 diabetes mellitus and associated cardiovascular risk with increased prevalence as people age [23]. This might be due to increased insulin resistance and increased fat metabolism with advanced age [24] . A study by Ekpenyong *et al.* [25] reported an increased prevalence of Type 2 diabetes mellitus in older patient and is in support of the current study. When the mean HbA1c between other patient characteristics (gender, education, marital status, occupation, income levels, residence and physical activity levels) was compared, there was no statistical difference. However, all participants showed a mean HbA1c of above 7% in all the studied characteristics (Table1) signifying that all patients had poor glycemic control despite their characteristics. Nevertheless, bivariate logistic regression showed that there was a tendency for better glycemic control as the educational level increased, with significant Odd Ratio (OR=O.069, 95% confidence interval; C1 0.006 – 0.774 P= 0.03) for participants who had attained tertiary education (Table 1). Indeed, studies have shown a relationship between good glycemic control and higher education attainment [26]; the current study is in support of this.

Additionally, as shown in Table 2, the current study showed that participants with HbA1c > 7% had statistically significant higher mean in TC (5.11±1.21mmol/l, P<0.01) and LDL (2.66±1.07 mmol/l, P=0.03) compared to those with HbA1c <7%. This was not surprising since other studies as well as International Diabetes Federation (IDF) and World Health Organization (WHO) have shown that elevated LDL>2.6mmol/l as well as TC>5.3mmol/l in Type 2 Diabetes patients are indicators of dyslipidemia, which is a major risk to glycemic management and related complications which include cardiovascular risk [2,3,27]. Indeed, elevated LDL and high TC are also patients' risk factors which predispose them to insulin resistance, a key contributor to poor glycemic control, microvascular and macrovascular complications as well as cardiovascular disorders [2,3]. For the other metabolic parameters (BMI, WC, WHR, TG, HDL, SBP and DBP), there was no significant difference in their means between groups with HbA1c >7% and those with HbA1c<7%. In the current study, higher means above the recommended levels were noted in TG, HDL, SBP and DBP for participant having a HbA1c >7% (Table 2). This might indicate that the participants were at risk of being obese, having hypertriglycemia as well as high blood pressure in addition to poor glycemic control. All these factors combined worsen the problem [2,3]. Moreover, high BMI and dyslipidemia are key indicators of obesity. In fact,

obesity is a major cause of insulin resistance as well as reduced insulin sensitivity[28]. Both reduced insulin sensitivity and increased obesity are key risk factors in Type 2 Diabetes patients and major causes of poor glycemic control [2,3].

The current study showed that the mean FBG (11.71±3.11mmol/l, P<0.01) was significantly higher in participants with HbA1c >7% compared to those with a HbA1c of <7% (Table 2). Additionally, the bivariate correlation (r =.0.766, P < .001) (Table 4) and univariate regression results (β1 = 0.679, P < .001) (Table 5) showed that FBG was significant and positively associated with HbA1c. Moreover, FBG after moderating with FHD (r= 0.586, p<0.01) was positively correlated with HbA1c (Table 4).The above results might signify that FBG is an important predictor of optimal glycemic control which worsens in the presence of FHD. According to Ghazanfari *et al.* [29] there is a significant relationship between FBG and HbA1c . A study by Gupta *et al.*[30] reports a positive correlation between FBG and HbA1c as well as higher mean HbA1c above 8% and is in support of the current study.

Additionally, the bivariate logistic regression (Table 3) showed that participants who had elevated SBP (OR= 0.273; 95% CI 0.110 - 0.680, P value <0.01) and elevated TG (OR= 0.392; 95%CI 0.16 - 0.95, P value = 0.04) were significantly at risk of poor glycemic control compared to those with normal levels (Table 3). All the other metabolic parameters had no statistically significant associations (Table 3). Elevated (BP) defined by either an elevated SBP and/or elevated DBP [16] as well as elevated TG are key risk factors and related complications to Type 2 diabetes [2,3]. Studies as well as IDF and WHO have shown that poor glycemic control in Type 2 diabetes patients have been associated with increased blood pressure as major risk factors as well as associated complications [2,3,27]. The bivariate regression (Table 4) showed positive relationship between DBP and SBP after moderating with FHD (r=0.168, p<0.05 and r=0.181,p<0.05, respectively) with HbA1c supporting the evidence that elevated blood pressure is a risk factor to Type 2 diabetes mellitus that may worsen in the presence of a FHD [1,16,17].

Moreover, the current study showed that there was a strong positive correlation between FHD with HbA1c (r=0.165, p<0.05) (Table 4). Since only FBG, FHD, SBP*FHD, DBP*FHD and FBG * FHD had a significant relationship with HbA1c (Table 4), they were subjected to further analysis using linear regression $Y = \beta0 + \beta1X1 + \varepsilon$; $Y = \beta0 + \beta1X1 + \beta1X2 + \varepsilon$ and $Y = \beta0 + \beta1X1 + \beta2X2 + \beta3X2Z1 + \beta4X2Z2 + \varepsilon$ to determine whether they had positive effects on glycemic control (HbA1c) in patients with Type 2 Diabetes. (β0 is the Y intercept /constant; βi is the slope coefficient representing relationship of the associated of independent variable Xi where; X1: FBG; X2: FHD; X2Z1: FHD *SBP; X2Z2- FHD *DBP and ε: the error term). The stepwise method was used for multivariate analysis.

Multivariate linear regression (Table 5) showed that there was a statistically significant relationship between FBG and HbA1c (β= 0.0679, p= 0.000), in the first model. In model 2, a significant relationship between FBG and HbA1c (β= 0.671, p= 0.000) and; FHD and HbA1c (β = 0.119, p= 0.047) was observed. After inclusion of FHD as the moderating variables, a statistically significant relationship was only seen in moderated

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variable (FBG*FHD) (β= 0.640, P=0.02) with no relationship in the FBG and FHD. The R^2value was 0.462, 0.473, 0.493 and 0.488 indicating that 46.2%, 47.3%, 49.3% and 48.8% of the variations in HbA1c could be explained by FBS; FBG and FHD: FBG, FHD and FBG*FHD and FHD and FBG*FHD. The scatterplot of standardized predicted values versus standardized residuals showed that the data met the assumptions of homogeneity of variance and linearity and the residuals were approximately normally distributed. From the ANOVA analysis, the models were valid indicating that the independent variables FBG; FBG and FHD; FBG, FBG, FHD, FBG*FHD and FHD, FBG *FHD are good predictors of HbA1c (F (1,152) =129.42, P=0.000; F (2,152) =68.00, P= 0.000; F (3,152) =48.36, P= 0.000; F (2,152) =71.35, P= 0.000.

Studies have reported that FHD have been associated with reduced insulin sensitivity and increased insulin resistance [28,31]. Hence, this might explain the positive correlation between FHD and HbA1c in the current study[32]. Moreover, our findings are in support of studies that have indicated a significant association between FHD and HbA1c [28,31].

CONCLUSIONS

In conclusion, the study reported a significant relationship between HbA1c with advanced age and FHD. HbA1c was also significantly associated with high BP, high FBG and dyslipidemia (TC, LDL). These metabolic factors (BP, FBG, TC, LDL) in Type 2 diabetes mellitus patient increase the risk of macrovascular, microvascular as well as cardiovascular risk.

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Abbreviations

ADA	American Diabetes Association
AACE	American Association of Clinical Endocrinologists
ACE	American College of Endocrinology
WHO	World Health Organization
HbA1c	glycated hemoglobin
HbA	Hemoglobin A
AGE	Advanced Glycation End products
WC	Waist circumference
HDL-c	High Density Lipoprotein cholesterol
TG	Triglyceride
TC	Total Cholesterol
LDL-C	Low Density Lipoprotein
BMI	Body Mass Index
WC	Waist Circumference
WHR	Waist Hip Ratio
FBG	Fasting Blood Glucose
FHD	Family History of Diabetes
CCF	Congestive Cardiac Failure
CVD	Cardiovascular Disease
TL5H	Thika Level 5 Hospital
DCC	Diabetes Comprehensive Care Centre
MET	Metabolic Equivalent
GPO/POD	Glycerol Phosphate Oxidase Peroxidase
CHOD/POD	Cholesterol Oxidase Peroxidase
KNH-UoN/ERC	Kenyatta National Hospital-University of Nairobi Ethical Research Committee
NACOSTI	National Commission for Science Technology and Innovation
SD	Standard Deviation
SPSS	Statistical Package for Social Sciences
OR	Odds ratio
CI	Confidence Interval
ADDRF	Africa Doctoral Dissertation Research Fellowship
APHRC	Africa Population and Health Research Center
IDRC	International Development Research Centre
PAL	Physical activity levels
YLWD	Years lived with type 2 diabetes mellitus

Competing interests

The authors declare no competing interests.

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Availability of data and materials
All the data collection tools and data are in the custody of Thuita Ann and are available on request.

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Authors' contributions
All the authors contributed to the conception and design of the study. B.K, O.A and M.A supervised the study. T.A collected and analyzed the data as well as drafting of the manuscript. All the authors contributed to the interpretation of the results, revision and approval of the manuscript.

Ethics approval and consent to participate
Ethical approval to conduct the research was granted by Kenyatta National Hospital and University of Nairobi Ethical Committee (Permit No. KNH-ERC/A/232), while administrative approval was granted by the National Commission for Science, Technology and Innovation (NACOSTI) Permit No. NACOSTI/P/16/83452/10118; the Ministry of Interior and Co-ordination of National Government, County Commissioner Kiambu Permit No. ED.12/1/VOL.IV/92; Ministry of Education Kiambu Permit NoKBU/CDE/HR/4/VOL.II (138); County health officials and health facility administrators.

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Table 1: Characteristics of Type 2 diabetes mellitus patients at level 5 Hospital

Parameters	Totals	HbA1c mean±sd	P value+	HbA1c >7%	HbA1c <7%	Odd ratio	95% CI	P value++
Gender								
Male	62(40.5)	8.64±1.99	0.375	51(33.3%)	11(7.2%)	ref		
Female	91(59.5)	8.37±1.76		68(44.4%)	23(15.0%)	0.538	0.173-1.674	0.28
Age								
20-39	4(2.6)							
20-39	10(6.6)	8.23±1.28	0.463	9(75%)	3(25%)	ref		
40-49	29(19.1)	7.96±1.43		20(69%)	9(31%)	1.908	0.290-12.561	0.50
50-59	46(30.5)	8.71±1.73		34(73.9%)	12(26.1%)	2.016	0.319-12.720	0.47
60-69	42(27.6)	8.65±1.79		38(88.4%)	5(11.4%)	1.083	0.139-8.431	0.94
70-79	23(15.1)	8.52±1.99		18(78.3%)	5(21.7%)	2.294	0.242-21.775	0.47
Marital status								
Single	16(10.5)	7.84±1.94		10(62.5%)	6(37.5%)	ref		
Married	129(84.3)	8.61±1.20	0.235	102(77.1%)	27(20.9%)	0.466	0.019-11.183	0.64
Separated /divorced	5(3.3)	7.92±0.49		5(100%)		0.344	0.018 -6.648	0.48
widowed	3(2.0)	7.30±0.60		2(66.7%)	1(33.3%)	0.000	0.000	1.00
Education background								
Primary	84(54.9)	8.41±1.95	0.889	61(72.6%)	23(27.4%)	ref		
Secondary	54(35.3)	8.52±1.77		44(81.8%)	10(18.5%)	0.368	0.119 – 1.131	0.08
Tertiary	14(9.2)	8.70±1.73		13(92.9%)	1(7.1)	0.069	0.006 – 0.774	0.03*
None	1(0.7)	9.50		1(100%)		0.000	0.000	1.00
Occupation								
Formal	6(3.9)	7.85±1.43	0.705	4(66.7%)	2(33.3%)	ref		
Casual	10(6.5)	8.54±1.82		8(80%)	2(20%)	0.771	0.049 – 12.210	0.85

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Farming	63(41.2)	8.68±1.98		52(82.5%)	11(17.5%)	0.598	0.063 – 5.722	0.66
Business	48(31.3)	8.25±1.61		33(68.8%)	15(31.2%)	0.683	0.136 – 3.423	0.64
Unemployed	26(17.1)	8.57±2.10		22(84.6%)	4(15.4%)	1.689	0.354 – 8.068	0.51
Residence								
Rural	95(62.1)	8.67±1.94	0.110	78(82.1%)	17(17.9%)	ref		
Urban	58(37.9)	8.18±1.67		41(70.7%)	17(29.3%)	0.524	0.160 – 1.714	0.26
Income Levels								
<1000	72 (47.1)	8.69±1.85	0.434	61(84.7%)	11(15.3%)	ref		
>1001-5000	32 (20.9)	8.24±1.84		22(68.8%)	10(31.2%)	0.548	0.117 - 2.522	0.44
>5001-10000	23 (15.0)	8.06±1.78		17(73.9%)	6(26.1%)	1.594	0.341 - 7.457	0.55
>10000	26 (17.0)	8.59±1.94		19(73.1%)	7(26.9%)	1.584	0.333 – 7.539	0.56
FHD								
Yes	71 (46.4)	8.16±1.62	0.041	54(76.1%)	17(23.9%)	ref		
No	82 (53.6)	8.77±2.00		65(79.3%)	17(20.7%)	1.374	.532	0.51
YLWD								
1-4 years	89 (58.9)	8.55±1.95	0.343	66(76.4%)	21(23.5)	ref		
>5-10years	30 (19.6)	8.28±1.73		29(80%)	6(20%)	0.408	0.035 – 4.717	0.47
>10-15years	19 (12.4)	8.42±1.59		15(78.9%)	4(21.1%)	0.531	0.041 – 6.955	0.63
>15 -20years	10 (6.5)	9.25±1.99		9(90%)	1(10%)	0.552	0.039 – 7.916	0.66
>20years	5 (3.3)	7.22±1.00		3(60%)	2(20%)	0.106	0.004 – 2.645	0.17
PA								
Light	71 (46.4)	8.29±1.70	0.380	56(78.6%)	15(21.1%)	ref		
Moderate	73 (47.4)	8.51±1.96		55(70.2%)	18(29.8%)	1.448	0.144 – 14.615	0.75
Vigorous	9 (5.9)	9.03±2.22		22(84.8%)	4(15.4%)	3.038	0.298 – 31.016	0.35

n represents the number of participants while (%) represents the percentage

OR – Odds ratio; 95% CI- 95% confidence interval; * statistical significance at p value<0.05, ** statistical significance at p value<0.01 ref -reference point

PA: Physical activity; FHD: Family history of diabetes; YLWD: Years lived with diabetes; HbA1c: Glycated hemoglobin

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Table 2: Patient characteristics and metabolic parameters of the participants categorized by glycemic control levels

Parameter	HbA1c		P values [a]
	>7%	<7%	
	Mean±SD	Mean±SD	
Age (years)	56.79±11.61	53.56±11.78	0.111
BMI(Kg/m^2)	26.97±4.88	27.23±4.08	0.774
WC(cm)	100.62±10.04	101.62±9.18	0.604
WHR	0.96±0.097	0.97±0.083	0.984
DBP(mmHg)	89.25±9.68	87.64±9.10	0.389
SBP(mmHg)	145.34±19.51	138.35±21.42	0.074
FBG(mmol/L)	11.71±3.11	8.54±3.19	0.000*
TG(mmol/L)	2.32±1.12	1.92±0.90	0.060
HDL-c(mmol/L)	1.39±0.34	1.36±0.39	0.689
TC(mmol/L)	5.11±1.21	4.48±1.16	0.008*
LDL-c(mmol/L)	2.66±1.07	2.22±1.04	0.034*

*statistical significance at $p<0.05$; [a] independent t test

Data are presented as mean ± standard deviation of the mean. BMI: body mass index, WC: waist circumference; WHR: waist-to-hip ratio, SBP: systolic blood pressure, DBP: diastolic blood pressure, FBG: fasting blood glucose TG: triglycerides, HDL-c: high density lipoprotein –cholesterol LDL-c low density lipoprotein- cholesterol, TC: total cholesterol and HbA1c –glycated hemoglobin

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Table 3: Multivariate logistic regression between HbA1c and patient cardiovascular risk factors

Parameter		HbA1c>7% n (%)	HbA1c<7% N (%)	OR	95% CI	P value
Obese	Yes	25(75.8)	8(24.2)	1.215	0.442 – 3.340	0.706
	No	94(78.3)	26(21.7)	ref		
Elevated WC	Yes	106(76.3)	33(23.7)	5.801	0.668 - 50.366	0.111
	No	13(92.9)	1(7.1)	ref		
Elevated SBP	Yes	89(83.2)	18(11.8)	0.273	0.110 – 0.680	0.005*
	No	30(65.2)	16(34.8)	ref		
Elevated DBP	Yes	91(77.8)	26(22.2)	1.430	0.514 – 3.978	0.493
	No	28(77.8)	8(22.2)	ref		
Reduced HDL	Yes	31(70.5)	13(29.5)	1.745	0.713 – 4.269	0.223
	No	88(80.7)	21(19.3)	ref		
Elevated TG	Yes	81(81.8)	18(18.2)	0.392	0.161 – 0.954	0.039*
	No	38(70.4)	16(29.6)	ref		
Elevated LDL	Yes	58(85.3)	10(14.7)	0.288	0.056 -1.478	0.136
	No	61(718)	24(28.2)	ref		
Elevated TC	Yes	54(84.4)	10(15.6)	1.562	0.287 – 8.505	0.606
	No	65(73.0)	24(27.0)	ref		

n represents the number of participants while (%) represents the percentage; *statistical significance at p value<0.05, ref: represent reference point , OR- odd ratio, 95% CI- 95% confidence interval, HbA1c- glycated Hemoglobin

Obesity: BMI>30Kg/m^2; elevated WC: >90cm for men or >84cm for women; elevated SBP: >130mmhg; elevated DBP: >80mmhg; Reduced HDL cholesterol: <1.0 mmol/L for men or<1.3 mmol/L for women or specific treatment for this abnormality; elevated TG :> 1.7mmol/l; elevated LDL: >2.6mmol/l and elevated TC: >5.2mmol/l

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Table 4: Bivariate correlation between Glycemic controls (HbA1c) with patient characteristics

Parameter	HbA1c	
	r	P value
WC	-0.018[a]	0.83
HDL	-0.016 [a]	0.85
TG	0.022 [a]	0.79
FBG	0.699 [a]	0.000**
BMI	0.030 [a]	0.71
WHR	-0.017 [a]	0.83
SBP	0.041 [a]	0.61
DBP	0.076 [a]	0.35
LDL-C	0.019 [a]	0.82
TC	0.023 [a]	0.77
Age	0.102 [a]	0.21
Years lived with diabetes	-0.082 [a]	0.31
FHD	0.165[b]	0.045*
WC * FHD	0.138 [a]	0.09
BMI * FHD	0.152 [a]	0.06
HDL-C * FHD	0.104 [a]	0.06
TG * FHD	0.078 [a]	0.34
LDL-C * FHD	-0.109 [a]	0.18
TC * FHD	0.144 [a]	0.08
SBP * FHD	0.168 [a]	0.04*
DBP * FHD	0.181 [a]	0.03*
FBG * FHD	0.586 [a]	0.000*

**Correlation is significant at the 0.01 level (2-tailed); *Correlation is significant at the 0.05 level (2-tailed).

[a]Pearson correlation analysis. [b]Point biserial correlation

BMI: body mass index; SBP: Systolic blood pressure; DBP: diastolic blood pressure; HDL-: high-density lipoprotein cholesterol; LDL-C: low-density lipoprotein cholesterol; FBG: fasting blood glucose; TC: total cholesterol; TG: triglycerides; WC-waist circumference; BMI: body mass index; FHD: Family history of diabetes

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Table 5: Multivariate linear regression between HbA1c and participants characteristics

Model	Parameters	B	R squared	P value.	95% CI
1	**FBG[a]**	0.679	0.462	0.000	0.307 – 0.436
2	**FBG[a]**	0.671		0.000	0.303 –0.431
	FHD[a]	0.119	0.476	0.047	0.006 -0.874
3	**FBG[a]**	0.252		0.19	-0.070– 0.346
	FHD[a]	-0.317		0.11	-2.638 – 0.283
	FBG*FHD[b]	0.640	0.493	0.02	0.020 – 0.275
4	**FHD[a]**	-0.553		0.000	-2.676 –1.428
	FBG*FHD[b]	0.988	0.488	0.000	0.189 – 0.267

HbA1c-Glycated hemoglobin; FBS-fasting blood glucose; FHD- Family history of diabetes

β- standardized regression coefficient, statistical significant $p<0.05$, 95% CI- 95 % confidence interval, [a] –independent variables included in the regression , [b] - moderated variables included in the regression

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