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ORIGINAL ARTICLE

Association of Blood Glucose and Lipid Profile Concentrations in Diabetic Patients Attending Gisenyi District Hospital in Rwanda: A Cross-Sectional Study

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ABSTRACT

Background: Poor glycemic monitoring of type 2 diabetes mellitus has been linked with dyslipidemia and this led to an augmentation of mortality in diabetic patients. This study assessed the association of blood glucose and serum lipid concentrations in type 2 diabetic patients at Gisenyi District Hospital in Rwanda.

Methods: This investigation was cross-sectional and used the Cochran formula ($n = Z^2PQ/d^2$) to estimate the number of participants. Predisposing aspects of dyslipidemia such as age, gender, blood pressure, and BMI were obtained from the participants. Blood glucose was tested in capillary blood samples using Accu-Check Aviva and lipid profiles were checked in blood serum drawn from each participant, using Cobas C311. Ranges for dyslipidemia considered were: TC < 200 mg/dl, TG < 150 mg/dl, LDL-C < 100 mg/dl, 51-60 mg/dl for females, and HDL-C 41- 60 mg/dl for males. A transformed Friedewald formula was utilized to quantify LDL-C. The chi-square test (X^2) was considered to investigate the association between categorical variables, whereas Pearson's coefficient was utilized to find out the correlation between continuous variables.

Results: A significant association was noted between the BMI and hyper TC ($X^2 = 9.936$; $p = .001$), hyper TG ($X^2 = 10.761$; $p = .001$), and hyper LDL-C ($X^2 = 10.410$; $p = .001$), whereas the association was not significant with low HDL-C ($X^2 = 2.416$; $p = .137$). A positive significant correlation was noticed between blood glucose and TC ($r = 0.678$, $p = 0.000$) and between blood glucose and LDL-C ($r = 0.293$, $p = .039$). A positive no-significant association was noted between blood glucose and TG ($r = 0.163$, $p = .259$), whereas a negative no-significant link was between blood glucose and decreased HDL-C ($r = -0.126$ $p = .381$).

Conclusion: A significant association was noted between the BMI and TG, TC, and LDL-C, but the link with HDL-C was not significant as it was for age, gender, and blood pressure with serum lipids. Blood glucose levels were positively linked with TG, TC, and LDL-C levels, but negatively linked with HDL-C. Thus, poor control of type 2 diabetes results in increased serum concentrations of harmful lipids.

BACKGROUND

Globally, 415 million people were diabetic and 14.2 million of them lived in Africa. The occurrence of diabetes mellitus type 2 (T2DM) is due is abnormalities in carbohydrate, lipids, and protein metabolism mainly due to an augmentation in insulin resistance in overweight and obese individuals or resulting from insufficient quantity of insulin production.[1] T2DM is often associated with defects in lipids metabolism and dyslipidemia that trigger cardiovascular disease (CVD) and increase the prevalence of coronary artery disease (CAD) and other macrovascular complications.[2] Alteration of one or more lipids and lipoproteins in type 2 diabetes contributes to oxidative stress and formation of free radicals which damage the endothelial tissue and accelerate the progression of atherosclerosis in blood vessels and the subsequent CVD. In sub-Saharan Africa, estimates have shown that 30 percent of patients admitted for CVD had type 2 diabetes mellitus.[3, 4]

The important risk aspect, in the development of CVD in T2DM patients, is abnormalities of the lipid profile parameters and comorbidity with high blood pressure in old age patients.[5] The risk increases with elevation of TC, TG, LDL-C, and decreased HDL-C in the blood of patients.[6] CVD or complications are decreased by the normal lipid profiles especially HDL that circulate in the blood because of its role of removing bad cholesterol (LDL-C) from the blood. The reduction of uptake of free fatty acids that circulate in the blood may be increased by TG hydrolysis owing to the lipase action. This may increase free fatty acids that

play in favor of insulin resistance and atherogenic dyslipidemia.[7,8] Elevated remnant lipoprotein is associated with high triglycerides because it is composed of high cholesterol and triglycerides.[9, 10]

Extensive research on atherogenic dyslipidemia and the risk of CVD in type 2 diabetic patients has been done in developed countries. However, in sub-Saharan African countries, particularly in Rwanda, few studies have been carried out to understand the pattern of dyslipidemia and its link with hyperglycemia in type 2 diabetic patients.[9,10] The present research was conducted to investigate the effect of abnormal blood glucose levels on lipid profile parameters in type 2 diabetic patients. Thus, it will provide insight into the regulation of dyslipidemia to reduce CVD-related mortality.

METHODS

Study Site

This research was conducted at Gisenyi Hospital, situated in the Gisenyi sector of the Rubavu district, on the banks of Kivu Lake. The hospital treats patients referred from the health centers of Rubavu, Rutsiro, and Nyabihu districts, as well as patients coming from Goma town of the Democratic Republic of Congo (DRC). On average, 70 patients with diabetes complications are received monthly in the outpatient diabetic clinic at Gisenyi Hospital for regular follow-up or admitted in the hospital's wards to monitor severe complications before being re-sent to their health centers of origin upon case improvement.

Study Design

A cross-sectional investigation was carried out to collect quantitative data and to check the correlation between the amounts of blood glucose and lipid profiles of the study participants. Blood specimens were collected from diabetic patients selected purposively among all patients who attended Gisenyi District Hospital during the period of the study, from September to December 2021. Capillary blood samples were used to measure the amount of glucose whereas serum samples obtained by venipuncture were utilized to measure the amount of TG, HDL, and TC.

Study Population

All patients suffering from type 2 diabetes who were referred by health centers to Gisenyi Hospital from September to December 2021 were considered in the investigation. However, study clients who met inclusion criteria and voluntarily accepted to participate were selected for the investigation.

Inclusion and Exclusion Criteria

All type 2 diabetes mellitus patients aged 20 years or above, in the overnight fasting state, and who were not under therapy for cardiovascular diseases were included in this study. Diabetic patients under 20 years and who were not fasting, women patients with gestational diabetes, and diabetic patients with cardiovascular diseases under treatment with lipid-lowering medication during the investigation period were not selected for the study.

Sample Size

To determine the required sample size, Cochran's formula: $n = Z^2PQ/d^2$ was used, where $Z = 1.96$ was the statistic corresponding to the 95% confidence interval, $P = 0.032$ was the approximated prevalence of type 2 diabetes in the population at risk[11], $Q = 1 - P = 0.968$ and $d = 0.05$ was the margin of error allowable. A sample size of 46.6 type 2 patients was calculated and 50 diabetic patients were purposively selected for the study participation.

Ethical Consideration

Ethical acceptance was given by both INES Ruhengeri and the Authorities of Gisenyi District Hospital. A written informed consent was given to each study client to decide willingly to participate in the investigation after being given the guarantee of confidentiality, anonymity, and privacy about the information provided.

Sample Collection and Testing

Blood pressure was measured, by a qualified nurse from study diabetic clients, using the Belsk digital blood pressure monitor (Northfield, IL 60093 USA). The body height and weight were quantified utilizing an appropriate instrument (Mechanical Brecknell HS-200M scale, UK). A systolic blood pressure of ≥ 140 mmHg and diastolic blood pressure of ≥ 90 mmHg were considered for hypertension.[12] The BMI was categorized as underweight (BMI < 18.5 kg/m^2), normal weight (18.5 ≥ BMI ≤ 24.9 kg/m^2), overweight (25 ≤ BMI < 30 kg/m^2), and obese (BMI ≥ 30 kg/m^2). Blood glucose was tested in capillary blood samples by glucose oxidase and peroxidase methods using Accu-Check Aviva (68305 Mannheim, Germany). The results were categorized as normal glycemia (75-120 mg/dl), hypoglycemia (< 75 mg/dl), or hyperglycemia (> 120 mg/dl).[13]

Four milliliters of venous blood were collected in a red top tube with a clot activator collected from each study participant by venipuncture using a 21G needle. It was then subjected to centrifugation at 3000 rpm for five min and the obtained serum was used to test TG, TC, and HDL. Humastar 80 Auto Analyzer (Human, Wiesbaden. Germany) was utilized to measure the concentration of TC, TG, and HDL in sera. The modified Friedewald formula was utilized to calculate LDL-C (mg/dl) = (Non-HDL-C × 90%) − (TG × 10%).[14] The concentration of TC, TG, and HDL was quantified at 546 nm. The normal values defined were < 200 mg/dl for TC, < 150 mg/dl for TG, < 100 mg/dl for LDL-C. For, HDL-C, values considered were 41- 60 mg/dl for males, and 51-60 mg/dl for females.[15] All reagents, controls, and calibrators were stored in a fridge at 2-8 °C.

Statistical Analysis

SPSS (Windows version 23.0, IBM Corp., Armonk, NY, USA) was utilized to determine the variables' frequency. The Chi-square test was utilized to check the link between categorical variables, whereas Pearson's correlation coefficient was utilized to ascertain the association between continuous variables. The results were presented in tables and graphs. Analysis was done at the 95% confidence level and the significance was considered when $P < .05$.

RESULTS

Clinical Aspects and Social Demographics of Study Participants

The study recruited 50 patients with type 2 diabetes. They were tested for blood glucose and serum lipid profile levels. Table 1 illustrates clinical aspects and social demographics such as age, gender, and hypertension status of diabetic patients. Middle age was the majority (60%) of the study population showing that type 2 diabetes mellitus affects mostly that category of people. There was an almost equal number of females and males. The results highlight that the majority (78%) of the study participants were hypertensive.

TABLE 1: Some Aspects of Study Patients

Variables	Frequencies
Age groups (years)	
[20-39]	3(6%)
[40-59]	30(60%)
≥60	17(34%)
Gender	
Male	24(48%)
Female	26(52%)
Blood pressure status	
Normotensive	11(22%)
Hypertensive	39(78%)

Link of Clinical and Demographic Aspects with Dyslipidemia

The association of clinical and demographic characteristics with dyslipidemia was investigated. The results in Table 2 highlight a statistically significant association between BMI and hypercholesterolemia, hypertriglyceridemia, and hyper LDL-C ($P < .05$). However, the BMI was not significantly associated with low HDL-C, male and female gender, and between age groups ($P > .05$). Similarly, the blood pressure was not statistically significantly associated with hyper TC, hypercholesterolemia, hyper-LDL-C, low-HDL-C, and hyper-TG ($P > .05$).

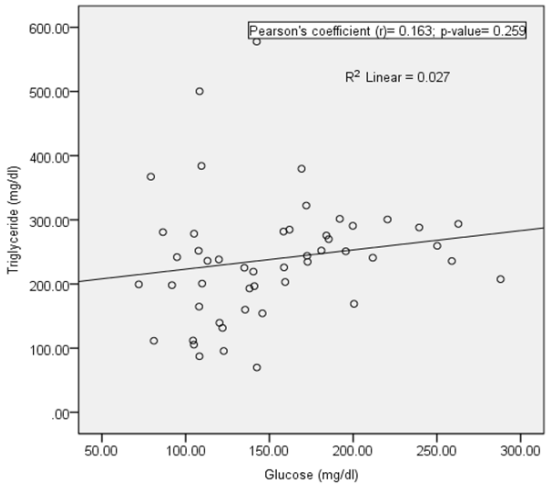
Correlation Between Blood Glucose and Lipid Profile in Diabetic Participants

The correlation between blood glucose amounts and serum triglyceride concentrations was studied. A positive no-significant correlation (r = 0.163, P =.259) between blood glucose with triglyceride concentrations was noticed (Figure 1). A negative no-significant correlation (r = -0.126 p =.381) between blood glucose and HDL-C was also noted (Figure 2). The study showed a significant positive correlation (r = 0.293, P = .039) between blood glucose and LDL-C concentrations as it can be seen in the figure 3. Figure 4 also shows an important positive link between blood glucose and total cholesterol (r = 0.678, P = .000).

Correlation Between Triglyceride and Blood Glucose

The results showed that blood glucose levels correlated positively with triglyceride in diabetic patients. That gives the idea that as glucose increases, triglyceride increases.

FIGURE 1: Correlation between Blood Glucose and Triglyceride Concentrations



Correlation Between High-Density Lipoprotein and Blood Glucose

Figure 2 represents the correlation between glucose and HDL in type 2 diabetic patients. It displays a downward regression line revealing the fact that glucose and high-density lipoprotein are inversely correlated.

FIGURE 2: Correlation between Blood Glucose and HDL-C levels

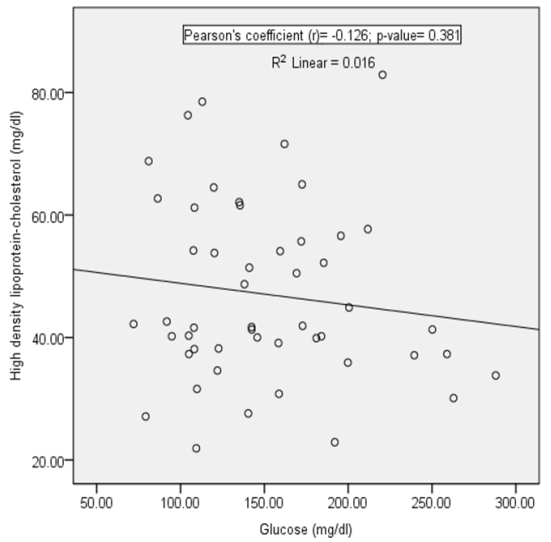


TABLE 2: Link of Clinical and Demographic Aspects with Dyslipidemia

Variable	Number of diabetic n (%)	Hypercholesterolemia n (%)	Hypertriglyceridemia n (%)	Low HDL n (%) n (%)	Hyper LDL n (%)
Age groups (years)					
[20-39]	3	0(0)	0(0)	2(66.6)	2(66.6)
[40-59]	30	23(76.6)	22(73.3)	10(33.3)	19(63.3)
[60-79]	16	10(62.5)	9(56.2)	1(1)	10(62.5)
≥ 80	1	1(1)	1(1)	0(0)	1(1)
Chi-square (df)		3.792 (3)	1.987 (3)	2.863 (3)	2.619 (3)
P Value		.259	.542	.320	.416
Sex					
Males	24	16(66.6)	14(58.3)	7(24.1)	18(75)
Females	26	17(65.3)	18(69.2)	6(23)	13(50)
Chi-square (df)		0.871 (1)	1.392 (1)	2.071(1)	1.009 (1)
P Value		.35	.24	.16	.32
BMI (kg/m2)					
Normal weight (18.5-24.9)	27	13(48.1)	11(41)	13(41.1)	22(81.4)
Overweight and obese (>25)	23	21(91.3)	20(87)	9(39.1)	19(83)
Chi-square (df)		9.936 (1)	10.41(1)	2.416 (1)	10.761 (1)
P Value		.001*	.001*	.137	.001*
Blood pressure (mmHg)					
Hypertension	32	17(53.1)	14(45)	8(25)	25(78.1)
Non-hypertension	18	12(67)	7(39)	3(17)	13(72.2)
Chi-square (df)		0.7439(1)	0.411 (1)	0.219 (1)	0.71191)
P Value		.340	.563	.643	.406

*P value significant (<0.05); (df): degrees of freedom

Correlation Between Low-Density Lipoprotein and Blood Glucose

Figure 3 shows the value of the Pearson correlation coefficient to explain the correlation between LDL and blood glucose.

Correlation Between Blood Glucose and Total Cholesterol

Blood glucose and serum triglyceride exhibited a positive moderate correlation statistically significant (r = 0.678; P < .001) with an increase in blood glucose level causing a 46 percent increase in total cholesterol (R^2 = 0.460) (Figure 4).

FIGURE 3: Correlation between Blood Glucose and LDL-C Levels

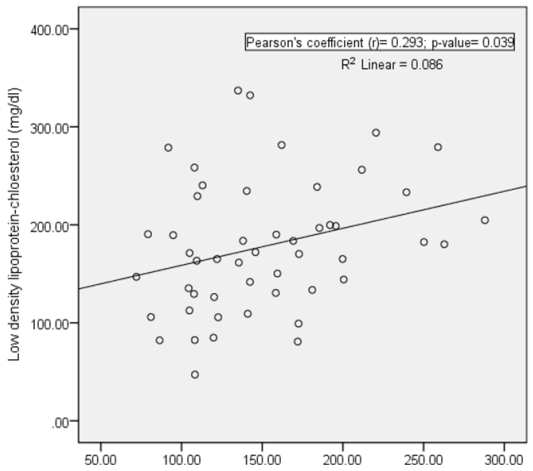
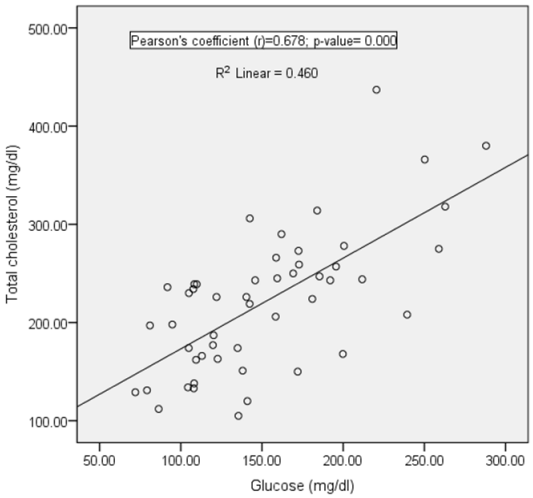


TABLE 4: Correlation between Blood Glucose and Total Cholesterol Levels



DISCUSSION

Link of Demographic and Clinical Aspects with Dyslipidemia

Of all the current study clients, the male-to-female ratio was 1:1.08. This shows that type 2 diabetes is almost equally prevalent in males as in females, contrary to a study in Ghana in which diabetes was more prevalent in females than in males.[16] Majority of the study clients in the current investigation were aged 40 years and above. This is the age group in which the majority of study participants had dyslipidemia. Blood glucose may have many effects on the vascular endothelium which leads to the development of dyslipidemia.[17]

The association between age, gender, BMI, and blood pressure with lipid parameters was assessed. It did not demonstrate any statistical significance because the lipid parameters did not differ significantly with demographic and clinical aspects. Studies have indicated that old age is a vital risk indicator for the occurrence of type 2 diabetes and body lipid abnormalities.[18] It was shown in this study that dyslipidemia was more prevalent in participants aged 40 years or above. This indicates that older age is associated with dyslipidemia. Although the figures depicting the prevalence of dyslipidemia appear high, the present investigation could not demonstrate any significant link between age and dyslipidemia. Therefore, dyslipidemia may appear in type 2 diabetes at any patient's age. Similar studies reported no statistically significant association between age and the lipid profile parameters in diabetic patients.[19,20] Unlike the results of this study, other research revealed that the age of type 2 diabetic patients was significantly linked with elevated LDL-C and hypertriglyceridemia.[21] The difference may be due to the study populations. Thus, extensive research would unknot the paradox.

The absence of a significant association was noticed between gender and the lipid profile parameters. The results agree with a previous study that showed no statistical difference in serum levels of HDL-C, TG, TC, and LDL-C between genders.[10] However, conflicting findings reported that HDL-C was significantly higher in females compared to males.[20,22] It was found that the risk of dyslipidemia is exacerbated in females due to increment caused by sex hormones and body fats distribution.[23]

The dyslipidemia in type 2 diabetic patients is determined by obesity and overweight conditions.[23,24] From the results of this study, a significant association was observed between the BMI and TC, TG, and LDL-C, but no significant association with HDL-C. The same observation was reported by another study that highlighted the association of BMI with hyper TC, hyper LDL-C, and hyper TG.[10] The association between BMI and total cholesterol, triglycerides, and LDL-C may therefore be due to lifestyle changes. Hypertension may thus result from the accumulation of abnormal lipids in blood vessels of diabetic patients.[25] Several investigations have shown that hypertension was prevalent in type 2 diabetic patients.[26,27] The same finding was observed in the current study in which the majority of study clients were hypertensive although there was no significant association between blood pressure and hypertension. The results concurred with findings from similar research which found a high prevalence of hypertension among type 2 diabetes.[28] The results also agreed with a report from a study that hypertension could favor the atherogenic dyslipidemia risks.[15] However, the current study disagrees with another study regarding the significance of the association.[29] The inconsistencies can be attributed to the study setting, differences in sample size, and other factors.

Several studies reported that increasing the BMI accounted for a significant augmentation in the prevalence of lipid abnormalities.[30] This finding is in agreement with the data of the present investigation which has shown a significant link between BMI and lipid aspects, except for HDL-C, and the earlier study revealed that dyslipidemia is among the consequences of high BMI.[2,4,25]

Association of Blood Glucose and Serum Triglyceride Concentrations

Triglycerides serve as transporters of adipose fat and blood glucose to and from the liver where they are produced.[31] Hypertriglyceridemia in the blood is a contributor to the plaque formation inside of the walls of blood vessels leading to their narrowing and preventing normal blood flow with increasing risk of cardiovascular diseases.[32] Figure 1 shows a weak positive and no significant association between blood glucose with triglyceride concentrations. This result agrees with studies that reported a moderate positive and significant correlation between triglyceride and blood glucose.[10,33,34] Therefore, the concentrations of blood glucose can be utilized to prognosticate the serum TGs and cardiovascular risk due to alteration of lipoprotein caused by hyperglycemia which results in overproduction of VLDL-C, defect of VLD-L, decreased activity of lipoprotein lipase and apolipoprotein B leading to atherosclerosis.

Association Between Blood Glucose and HDL-C Concentrations

Lower than normal levels of serum HDL-C in diabetic

patients were reported to correspond with poor glycemic control or hyperglycemia, while patients with appropriate monitoring of blood glucose have elevated concentrations of serum HDL-C.[35] The results in this study revealed a lack of correlation between blood glucose and HDL-C concentrations. However, no significant association between the variables was noticed. Contrasting results were reported in other studies.[36,37] However, similar to this study, the levels of serum HDL-C were significantly lower in patients with high glycemia levels as compared to patients with low blood glucose.[22] However, the lack of statistically significant association ($P > .05$) and low rate of HDL-C and blood glucose level concomitant change ($R^2 = 0.016$) in the present investigation would not allow to ascertain that effective control of type 2 diabetes would correspond to increased serum level HDL-C as other biological confounding factors may be interplaying.

Association of Blood Glucose and LDL-C Concentrations

Hardening of the blood artery wall may be caused by the LDL because it accumulates LDL in the artery wall which narrows the blood vessel. This abnormality of LDL which is known as bad cholesterol may result from the impairment of blood glucose.[38] The results of this investigation showed a weak positive correlation between the blood glucose and serum LDL-C concentrations in the present study. These findings agree with those reported in several other studies providing further evidence that in poor glycemic control, the likelihood of a high concentration of LDL-C would be increased.[20,21,39] Therefore, blood glucose could be utilized to predict the level of LDL-C in diabetic patients because blood glucose can cause the defect of LDL which leads to the formation of plaque inside the artery.

Association Between Blood Glucose and Total Cholesterol Concentrations

Diabetic patients may possess various lipid abnormalities including TC. All these malformations are predisposing to the threat of cardiovascular ailments. In diabetes, this condition arises owing to abnormal metabolism, especially glucose catabolism, resulting in dyslipidemia and hyperglycemia.[40] In this study a moderate positive correlation between blood glucose and TC was noted. Similarly, other studies have reported a non-significant weak positive link between fasting blood glucose and TC in diabetic patients.[5,41-43] The result indicated that an augmentation in blood glucose concentration would correspond to hypercholesterolemia. Ultimately, the results imply that uncontrolled type 2 diabetes would lead to defects in cholesterol metabolism.

CONCLUSION

The study investigated the effect of clinical and demographic characteristics on the levels of serum lipids. A significant association was noticed between the body mass index and TG, TC, and LDL-C but the link with HDL-C was not as significant as it was for age, gender, and blood pressure with serum lipids. A correlation between blood glucose and serum lipid concentrations has thus been observed. Blood glucose concentrations were positively linked with TG, TC, and the bad cholesterol LDL-C levels, but negatively associated with HDL-C which is the good cholesterol. It can be suggested that failure to control type 2 diabetes results in elevated serum concentrations of harmful lipids. Thus, effective control of hyperglycemia in type 2 diabetic patients and periodic check and treatment of dyslipidemia can prevent associated adverse health outcomes.

Study Limitations

Biochemistry standard procedures were utilized in the present investigation to quantify TC, HDL-C, TG, LDL-C, and blood glucose, and therefore, the present results are correct and valid. Study patients in the present research were from Gisenyi district hospital of Rubavu district. Thus, the present results are not for Rwandan estimates as there are 30 districts with 42 hospitals across Rwanda.

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