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Relationship between Atherogenic Indexes and Fasting Blood Sugar among Diabetic Patients

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Abstract **Original Research Article**

Disorders in lipid profile levels participate in the generation of atherogenic dyslipidaemia, complications in patients with type 2 diabetes (T2DM), one of the strongest markers in predicting cardiovascular disease (CVD). In this study we investigated the fast blood sugar (FBS), lipid profile, and atherogenic indexes [atherogenic index of plasma (AIP); cardiac risk ratio (CRR); cardioprotective index (CPI); atherogenic coefficient (AC)] were calculated in males and females and compared control groups. There was a low positive correlation between FBS with a lipid profile ranging from ($r = 0.334$, $P < 0.043$), to ($r = 0.459$, $P < 0.027$), and a very strong between atherogenic indexes with a lipid profile ranging from ($r = 0.804$, $P < 0.000$) to ($r = 0.950$, $P < 0.000$). Conversely, there was a strong negative correlation between CPI and lipid profile ranging from ($r = -0.663$, $P < 0.000$) & ($r = -0.768$, $P < 0.000$) and a very strong negative correlation with LDL ($r = -0.900$, $P < 0.000$) & ($r = -0.905$, $P < 0.000$) in male. In females, the correlation was positive and recorded at ($r = 0.213, 0.361$) between FBS and TG &VLDL. Besides, very strong correlation between AIP with TG ($r = 0.954$, $P < 0.000$), TC ($r = 0.572$, $P < 0.000$), and VLDL ($r = 0.456$, $P < 0.029$). While the correlation was strong between AC with LDL ($r = 0.829$, $P < 0.000$), it was very strongly positive with TC ($r = 0.943$, $P < 0.000$), finally, the correlation value in CPI was highly negative and ranged from ($r = -0.774$, $P < 0.000$), to ($r = -0.909$, $P < 0.000$), for TC and LDL respectively. In conclusion, the participants with high levels of FBS possess a highly significant positive correlation with atherogenic indexes (AIP, CRR, and AC) and a negative correlation with CPI values.

Keywords: Atherogenic indexes, cardioprotective index, atherogenic coefficient, Fasting blood sugar, Diabetic, Lipid ratio, cardiovascular disease.

1. INTRODUCTION

Noncommunicable diseases (NCDs) include hypertension, cancer, chronic respiratory diseases, cardiovascular disease, diabetes mellitus, obesity which appears by excessive calorie intake and decline in physical exercise, and dyslipidaemia which is generated by an imbalance between HDL- C and LDL- C [1].

Atherogenic dyslipidaemia (AD) is characterized by high triglyceride levels together with low HDL and high LDL cholesterol, besides a prolonged state of insulin resistance IR which enhances the release of free fatty acids from adipose tissue. This alteration in the lipid profile favors the accelerated development of atherosclerosis [2].

According to the etiology of atherosclerosis, cardiovascular disease (CVD), and atherogenic dyslipidemia frequently co-occurrence. Atherogenic dyslipidemia is one of the risk factors for the development of atherosclerosis. As a result of the expansion of atherosclerosis, the prevalence of cardiovascular disease (CVD) has increased. This disorder appears more clearly in those with high levels of lipids in comparison with normal ones [3].

It is important to note that one of the main risk factors for cardiovascular disease (CVD) is type 2 diabetes. Patients with type 2 diabetes (T2DM) have a 2-4 times higher risk of cardiovascular death than people without diabetes [4].

Furthermore, it has been estimated that the prevalence of chronic complications of diabetes ranged from 8.1% to 41.5% for retinopathy, 21% to 22% for albuminuria, 6.7% to 46.3% for nephropathy, and 21.9% to 60% for neuropathy [5].

Patients with type 2 diabetes have a better prognosis and lower risk of CVD and death when their CV risk factors are identified and controlled early. An effective indicator of the risk of atherosclerosis and coronary heart disease is the atherogenic index of plasma (AIP). The size of antiatherosclerotic lipoprotein particles is correlated with the AIP. Thus, this measurement captures the equilibrium between lipoproteins that are atherogenic and protective [6].

This study aimed to determine the relationship between variables that assess atherogenic risk (AD and LT) and scales that assess the risk of presenting insulin resistance.

2. MATERIALS AND METHODS

2.1. Subjects:

A total of 116 patients with T2DM, including 58 males the average age was 53.5 ± 6.55 years, and 58 females the average age was 53.5 ± 5.9 years. Besides control groups for males and females, one of the exclusion criteria was having an acute illness, liver, or renal impairment. The anonymity and confidentiality of the data collected were guaranteed at all times. All the processes of this study were governed by the ethical standards of the hospital, and the supervisor for the study was the only one who knew each participant's identity.

2.2. Biochemical Indicators Testing:

Lipid profile tests include Low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), total cholesterol (TC), triglyceride (TG), and FBS. All samples were checked in the central laboratory of the hospital after 12 hours of overnight fasting.

2.3. Atherogenic Indices:

After determining the concentration in mmol/L of total cholesterol (TC), total triglyceride (TG), HDL-c, and LDL-c fractions, atherogenic indices [AIP, CRR, AC, and cardioprotective index (CPI)] were calculated by using the values of lipid profile parameters in the following way [7].

Atherogenic index of plasma (AIP) = Log [TG/HDL]

Atherogenic coefficient (AC): AC = [TC-HDL/HDL]

Cardiac risk ratio (CRR): CRR = [TC/HDL]

Cardioprotective index (CPI): CPI= [HDL-c/LDL-c]

2.4. Statistical Analysis:

Participant characteristics were described by means and standard deviation. Initially, in each participant, we investigated the relationship between FBS and lipid profile, and at the second stage, we checked the relation between AIP and lipid profile which were measured using correlation tests. Statistical analysis was performed using the SPSS version 22. In all calculations, $p < 0.05$ was considered a statistically significant level.

3. RESULTS

The results of our current study are presented in Tables 1 and, 2 showing the association among the AIP, diabetic FBS, and Lipid profiles. Table 1 shows the association between diabetic FBS and blood lipid measurements, Table 2 shows atherogenic indexes.

Table 1: Descriptive statistics of comparison between two genders by multiple factors

Parameter	Male			Female		
	Control	30 -55 y	56 - 80 y	Control	30 -55 y	56 - 80 y
FBS (mg/dl)	88 ±11	193±35	182±46.9	85 ±10	195±47	203±41
TC (mg/dl)	132 ±18	214±55	229±42	121 ±16	199±48	202±29
TG (mg/dl)	76 ±12	296±142	244±96	73 ±14	304±101	285±75
HDL (mg/dl)	51 ±4.69	41±20	43±30	48 ±6.9	42±3.5	43±3.8
LDL (mg/dl)	14 ±2.23	115±45	130±45	14 ±2.8	98±37	104±28
VLDL (mg/dl)	56 ±19.7	59±28	48±19	54 ±15	61±20	57±15
Age	48 ±8	44 ±7.8	63 ±5.2	44 ±8.7	45±7.5	62±4.4

Table 2: Evaluation of atherogenic indexes

Parameter	Male			Female		
	Control	30-55 y	56-80 y	Control	30-55 y	56-80Y
AIP	0.173 ± 0.069	0.856 ± 0.194	0.716± 0.181	0.2 ± 0.119	0.828 ± 0.145	0.803 ± 0.118
AC	1.6 ± 0.375	4.184± 1.365	4.319± 1.098	1.6 ± 0.624	3.77 ± 1.187	3.65 ± 0.769
CRR	2.6 ± 0.375	5.184± 1.365	5.319± 1.098	2.6 ± 0.624	4.77 ± 1.187	4.65 ± 0.769
CPI	1.6 ± 0.556	0.357± 0.188	0.374± 0.130	3.5 ± 0.0.819	0.485 ± 0.189	0.448 ± 0.127

A total of 116 respondents participated in the study. Initially, in each participant, we investigated the relationship between FBS with TG & VLDL values, In the second stage, we checked the relation between

atherogenic parameters with FBS, and lipid profiles were measured using correlation tests.

A Pearson's correlation was run to determine the relationship among 116 subjects, divided into two groups 58 subjects to each according to gender, each group subdivided according to age from 30 to 55, and 56 to 80 years for male and female respectively.

Correlation Analysis of FBS based on the data analysis of different parameters of lipid profile in addition to atherogenic indexes. There was a low, positive correlation between FBS with TG (r = 0.334, P <0.043), and VLDL (r = 0.459, P <0.027), in addition, there was a very strong between AIP with TG (r = 0.950, P <0.000), and VLDL (r = 0.928, P <0.000). Also, AC & CRR-related indicators hold of very strong significant correlation with TC (r_{30}= 0.983, P < 0 000), (r_{56}= 0.934, P < 0 000), and LDL (r_{30}= 0.804, P < 0.000), (r_{56}= 0.830, P < 0.000), there was a moderate to strong negative correlation between CPI and TC (r_{30} = - 0.663, P < 0.000) & (r_{56} = 0.768, P < 0.000) and a very strong negative correlation with LDL (r_{30} = - 0.900, P < 0.000) & (r_{56} = 0.905, P < 0.000) in each group of age in male.

The same parameters were determined in the case of females, there was a low, positive correlation between FBS and TG (r = 0.334, P <0.043), and VLDL (r = 0.459, P <0.027), in addition, there was a very strong between AIP with TG (r = 0.950, P <0.000), and VLDL (r = 0.928, P <0.000). Also AC & CRR-related indicators hold of very strong significant correlation with TC (r_{30}= 0.983, P < 0 000), (r_{56}= 0.934, P < 0 000) and LDL (r_{30}= 0.804, P < 0.000), (r_{56}= 0.830, P < 0.000), there was a moderate to strong negative correlation between CPI and TC (r_{30} = - 0.663, P < 0.000) &(r_{56} = 0.768, P < 0.000) and very strong negative correlation with LDL (r_{30} = - 0.900, P < 0.000) &(r_{56} = 0.905, P < 0.000) in each group of age in male.

The same parameter was determined in the case of females, there was a positive correlation between FBS and TG&VLDL (r30, 56= 0.213, 0.361), and VLDL (r30,56 = 0.0213, 0.361), without significant degrees. Besides that, there was a very strong correlation between AIP with TG (r30 = 0.954, P <0.000), TG (r56 = 0.938, P <0.000), and TC (r30 = 0.572, P <0.000), VLDL (r56 = 0.456, P <0.029). The correlation was moderate between AC with TG (r30 = 0.671, P <0.000), TG (r56 = 0.551, P <0.006), while was strong between AC with LDL (r30 = 0.829, P <0.000), LDL (r56 = 0.715, P <0.000), but it was very strong positive with TC (r30 = 0.943, P <0.000), TC (r56 = 0.868, P <0.000), in the last the correlation value in CPI was highly negative with TC (r30 = - 0.696, P <0.000), TC (r56 = - 0.774, P <0.000), LDL (r30 = - 0.871, P <0.000), LDL (r56 = - 0.909, P <0.000). All results were recorded for males and females in each period of age where r30 meant 30 - 55 years and r 56 meant 56 - 80 years.

4. DISCUSSION

Over the past few decades, the relationship between diabetes mellitus and CVD has been thoroughly documented.

Cardiovascular disease (CVD) is the primary cause of death among those with type 2 diabetes (T2DM) [8].

Based on our conclusions, the correlation between FBS and lipid profile was evaluated, and it was discovered that there was a positive relationship between FBS and TG, TC, LDL, and VLDL-C, as well as with the atherogenic indexes, which were elevated in comparison with control, especially with TG and VLDL, which were all positively statistically significant FBS with TG (r = 0.334, P <0.043), and VLDL (r = 0.459, P <0.027), respectively, these results recorded for male and female.

It is worth mentioning that, our results were supported by a previous study (Kumar S. *et al*., 2022) who reports that women experience a larger increase in cardiovascular disease due to diabetes than males do. In line with higher triglyceride, very low-density lipoprotein C (VLDL-C), and lower high-density lipoprotein C (HDL-C) levels compared to men [9]. The results of this study were supported by a previous study. Wang L, *et al.*, 2022 and Hussain A *et al.*, 2017 show that those with higher blood glucose levels have a higher level of harmful lipids (TG, LDL, TC) as a component of a lipid profile that could increase their risk for T2DM complications [10, 11].

A ratio of lipids is more valuable than standard lipid components utilized alone because it more accurately represents the risk of cardiovascular diseases. It is assumed that individuals with high blood glucose levels have a high TC/ HDL-C ratio and are more likely to suffer stroke or atherosclerosis. Through Atherogenic rations which include the Atherogenic index of plasma AIP, Atherogenic coefficient AC, cardiac risk ratio CRR, and cardiac protective index CPI. Among those ratios, AIP has been reported to be a better biomarker for coronary artery disease and type 2 diabetes [12].

In our study, the Pearson analysis revealed a strong positive correlation between AIP which we propose to call “atherogenic index of plasma” which is represented as Log (TG/HDL-C), with TG and VLDL (r_{30}=0.950, p=0.000 and r_{56}=0.928, p=0.000) respectively. Furthermore, it has been suggested that AIP was a reliable indicator in the prediction of atherosclerosis and cardiovascular complications. Cai et al. observed a significant decrease in the atherogenic index of plasma (AIP) in the control group compared to coronary artery disease (CAD) [13].

In addition, our data were in agreement with (Vegan *et al*., 2014) other risk ratios such as TG/HDL

ratios have been related to T2DM and also predict cardiovascular disease [14].

Some lipid-related parameters have been used to predict the risk of CAD, these include the concentration of plasma lipids and lipoproteins, the ratio of TC / HDL-C, represented by the Cardiac risk ratio (CRR) or a combination with other parameters, like TC - HDL-C/HDL-C as an Atherogenic coefficient (AC) is the best lipid-related predictor of future cardiovascular events, the findings from this study are that AC & CRR-related indicators hold of very strong significant correlation with TC (r_{30}= 0.983, P < 0 000), (r_{56}= 0.934, P < 0 000), and LDL (r_{30}= 0.804, P < 0.000), (r_{56}= 0.830, P < 0.000) for male and female. These results come in agreement with (Li *et al*., 2023) the values of the ratio of TC to HDL (P < 0.001), and AI (P < 0.001), positively correlated with the CAD severity were significantly elevated in the CAD group than the non-CAD group. which may be used as a noninvasive biomarker for the evaluation of the complexity of CAD in clinical practice. In addition, they could serve as independent predictive factors for CAD and CAD severity [15].

In agreement with our conclusion, patients with a lower HDL-C and higher LDL-C demonstrate more severe coronary artery severity. Conversely, high HDL-C reducers the atherogenic effects of oxidized LDL in artery walls. Because both of them act conversely to each one, therefore, HDL/LDL is a better risk predictor for CAD than LDL-C or HDL-C alone [16].

Conversely, the above data in our study table (2) there was decreasing in the CPI values compared to the control in males and females in different categories of ages only inverse correlation was noted in the cardioprotective index CPI, The assessment of cardioprotective index was based on HDL-c/LDL-c ratio, there was a negatively statistically significant correlation between CPI with TC (r30 = - 0.696, P <0.000), TC (r56 = - 0.774, P <0.000), and LDL (r30 = - 0.871, P <0.000), LDL (r56 = - 0.909, P <0.000). Further, the negative correlation gives evidence for decreasing the rate of protection according to the elevation, especially in lipid ratios. These indices are valuable in assessing the risk of developing cardiovascular diseases; the more accurate the increase in AIP, AC, CRR, and decrease in CPI, the more there is a predisposition for cardiovascular disease.

5. CONCLUSION

In conclusion, as we notice diabetes is an important risk factor for CVD and is closely related to dyslipidemia. The results of our study show that participants with high levels of FBS possess high levels of harmful lipids especially TG, TC, LDL, and VLDL., in contrast, low levels of cholesterol scavenger lipoprotein HDL. According to that, we noticed there were significantly high atherogenic indices (AIP, CRR, and AC) where corresponding with an increase in TG, TC, and LDL, and lower CPI values which coincide with a negative correlation with the level of fasting blood glucose using Pearson correlation analysis.

Recommendation: Since our study was hospital-based, its only restriction is that its conclusions cannot be immediately applied to the general public without first completing a population-based study.

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