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LIPOPROTEIN (a) LEVEL AMONG PATIENTS WITH TYPE 2 DIABETES MELLITUS AND PREDIABETES IN COMPARISON WITH HEALTHY CONTROLS

Barhav Issa Abdullah [a], Sherwan Ferman Salih [b,*]

[a] BSc in Chemistry, Duhok University, College of Health Science (Barhav.abdullah@uod.ac)
[b] Clinical Biochemistry, Duhok University, College of Medicine (sherwan.salih@uod.ac)

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ABSTRACT:

Objective: Diabetes mellitus type 2 is a chronic endocrine condition defined as high blood glucose concentration and produced by either insulin resistance or relative lack of insulin, Prediabetes is a metabolic disorder defined by high blood glucose levels that are below the diagnostic threshold for diabetes mellitus. This study aimed to measure lipoprotein (a) levels in individuals with type 2 diabetes mellitus and prediabetic individuals.
Methods: A cross-sectional research was performed at Diabetes Unit at Azadi Teaching Hospital, Kurdistan Region, Iraq. The study group consists of 235 participants, 85 type 2 diabetic patients, 60 prediabetic individuals and 90 individuals as control group.
Results: Mean levels of Lipoprotein (a) were higher in patients with type 2 diabetes mellitus (60.43±13.19 mg/dl) and prediabetic individuals (42.53±11.65 mg/dl) in comparison with healthy control (27.3±11.16 mg/dl). Moreover, there was a higher prevalent rate of abnormal high lipoprotein (a) among type 2 diabetic patients (69 ,81.1%) and prediabetic individuals (10, 16.7%).
Conclusion: High mean level of lipoprotein (a) and high prevalence rate of abnormal high lipoprotein (a) were observed in type 2 diabetic patients and prediabetic individuals.

KEY WORDS: lipoprotein (a), diabetes mellitus type 2, prediabetes.

1. INTRODUCTION

Diabetes mellitus type 2 is an endocrine disorder described by elevated blood glucose concentration caused by defect in insulin whether decrease production of insulin (β-cell dysfunction) or insulin resistance (Chamberlain, 2016; Sudesna, 2017). Prediabetes is an intermediate metabolic condition between normal and diabetes mellitus with blood glucose level more than the normal and lower than that of diabetes mellitus (Bansal, 2015). Most people are not aware of prediabetes, because they are asymptomatic (Stepanek, 2018). Type 2 diabetes mellitus and prediabetes are emergence risk factors for development of cardiovascular disorders, as these are associated with accelerated atherosclerosis (Arnold, 2020; Fan, 2017).
Lipoprotein (a) is an LDL particle produced by liver and made of apo (a) and apo B100 (Mach, 2019). Structurally lipoprotein (a) is similar to plasminogen and LDL (Maranhão, 2014). This similarity in structure of lipoprotein (a) enhances it to behave as a prothrombic effect and atherogenic effect. Moreover lipoprotein (a) is regarded as a specific risk factor for arterial heart disease development as it enhances atherosclerosis development (Shah, 2020).
Diabetes mellitus is a crucial risk factor for the onset of cardiovascular diseases, such as arterial heart disease, myocardial infarction, and cardiomyopathy (Weitzman, 2016; Viigimaa, 2020). Moreover, prediabetes is another risk factor of cardiovascular disease as the traditional risk factors such as hypertension, abnormal high lipids and obesity as common among individuals with prediabetes (Stacey, 2015; Bonora, 2003). Lipoprotein (a) is one of the factors that contributes to initiation and progression of atherosclerosis, because it consists of LDL, apoB-100 core, and apolipoprotein (a), which are associated with regulating platelet aggregation, mediating inflammation, and inducing vascular remodeling (Riches & Porter, 2012; Klesareva, 2016).
the relationship of lipoprotein (a) with type 2 diabetes mellitus and prediabetic individuals was controversial. Different studies showed different results of lipoprotein (a) level (Shah, 2020; Ogbera, 2010; Jin, 2019; Joseph, 2016; Ren, 2021). Therefore, this study aimed to evaluate lipoprotein (a) level among type 2 diabetic patients and prediabetic individuals in comparison with healthy controls, analyze the relationship between lipoprotein (a) level, lipid profile and atherogenic indices in patients with type 2 diabetes mellitus and individuals with prediabetes and ascertain the relationship between lipoprotein (a) level and percentage of HbA1c in type 2 diabetic patients.

2. MATERIALS AND METHODS

This study was performed cross-sectionally at Medical Laboratory Department, Duhok University for a period of 8 months interval from November 2021 to July 2022 and it was accepted by the ethic committee, Directorare of Health, Duhok governorate (15092021-9-10). A total of 235 participants (85 type 2 diabetic patients, 60 prediabetic individuals and 90 healthy individuals as a control group) were enrolled in this study. The study included 121 male and 114 female participants. Type 2 diabetes mellitus was identified according to American Diabetes Association (fasting serum glucose level of 126 mg/dL or higher, 2-hour serum glucose level of 200 mg/dL or higher during oral glucose tolerance test, random serum glucose of 200 mg/dL or higher, HbA1c level of 6.5% or higher) (Care, 2019). Prediabetic individuals were obtained from relatives of type 2 diabetic patients and the diagnosis of prediabetes depend on American Diabetes Association, (Impaired Fasting Glucose when fasting blood glucose level of

* Corresponding author

100 to 125 mg/dL, Impaired Glucose Tolerance when blood glucose level of 140 to 199 mg/dL 2- hours after taking 75-gram glucose solution, HbA1c levels between 5.7% and 6.4%) (Draznin, 2022). The healthy control individuals were chosen from medical staff and college employers who were healthy, with no history of chronic disease, no history of diabetes mellitus among first degree relative, non-smoker and non-alcoholic. Participants with liver diseases, renal diseases, thyroid diseases and individuals who were taking hypolipidemic drug, steroid drugs, and pregnant women were not included in the research.

A meeting interview conducted to fill out a questionnaire form created to meet the requirements of the study. The questionnaire form included questions such as; name, age, date of birth, gender and family history of diabetes mellitus. Anthropometric parameters included measurement of Waist Circumferences, Weight, Hight and determining of Body Mass Index. The Body Mass Index was determined as the weight (kg)/height (m)2 (Nuttall, 2015).

All participants were informed to attend Azadi Teaching Hospital, Clinical Biochemistry Department. Following an overnight fast, blood samples were drawn from participants into convenient gel vacutainer tubes and vacuum tube containing K3 ethylenediaminetetraacetic acid as anticoagulant for estimation of HbAlc levels by cobas 6000 (Hitachi, Roche) based on the turbidimetric inhibition immunoassay for hemolyzed whole blood. The serum removed from gel vacutainer tubes for measuring glucose, lipid profile and insulin using cobas 6000 (Hitachi, Roche) depending on Enzymatic, colorimetric method and sandwich electrochemiluminescence immunoassay respectively, and the levels of apolipoprotein A, apolipoprotein B and lipoprotein (a) were estimated in serum by using (Enzyme-Linked Immunosorbent Assay, assaygenie kit, Europe). Atherogenic indices or profile (lipoprotein ratio) were calculated from individual parameters of lipid profile as follows: total cholesterol/HDL-C ratio (normal value less than 4.5), triglyceride/HDL-C ratio (normal value less than 3.0), LDL-C/HDL-C ratio (normal value less than 2.5), ApoB/ApoA ratio (normal value less than 0.9 for men and less than 0.8 for women), non-HDL-C was computed as total cholesterol minus HDL-C (normal value less than 130 mg/dl) (Hussain, 2020). Serum lipid profile abnormalities depended upon the National Lipid Association (Jacobson, 2015). Homeostatic Model Assessment for Insulin Resistance (HOMA-IR) was derived from the following formula: HOMA-IR = [fasting glucose] (mg/dl) × [fasting insulin] (μU/ml)/405 (normal value of less than 3.0) (Lotfy, 2017).

3. STATISTICAL ANALYSIS

The Statistical Package for Social Sciences (SPSS version 26) was used to carry out the statistical analysis. The results were expressed as mean ± SD, one-way ANOVA was used for comparison between studied groups. Independent t-test and Chi-square test was performed to compare the differences between the two groups. P value less than 0.05 is regarded as statistically significant.

4. RESULTS

In Table 1, basic characteristics of studied groups were shown. Type 2 diabetic patients mean age was 47.2 ± 6.51 that is significantly higher than of prediabetic (43.46±9.78 years) and healthy control individuals (35±5.90 years). preponderance of type 2 diabetic patients (68, 80%) and prediabetic individuals (41, 68.3%) were equal or more than 40 years old. Two third of type 2 diabetic patients were female comparatively to less than half of prediabetic and control individuals.

There was a statistically significant انك difference of body mass index and waist circumferences between studied group. Majority of type 2 diabetic patients (74, 87.1%) and prediabetic individuals (54, 90%) were overweight and obese, with central obesity (69, 81.2%; 42, 70%) respectively.

Table 1 Basic characteristics of the type 2 diabetic patients, prediabetes and control individuals

Character	Type 2 diabetes n=85	Prediabetes n=60	Control n=90	P value
	Mean ± SD, (N%)	Mean ± SD, (N%)	Mean ± SD, (N%)	
Gender	34(40%)	36(60%)	51(56.7%)	
Male	51(60%)	24(40%)	39(43.3%)	0.027
Female				
Age(years)	47.2±6.51	43.46±9.78	41.35±5.90	<0.0001
<40 (years)	17(20%)	19(31.7%)	44(48.9%)	<0.0001
≥40 (years)	68(80%)	41(68.3%)	46(51.1%)	
BMI (kg/m2)	31.78±6.27	31.46±5.37	24.82±3.69	0.059
Normal	11(12.9%)	6(10%)	58(64.4%)	
Overweight	23(27%)	18(30%)	22(24.6%)	<0.0001
Obese	51(60.1%)	36(60%)	10(11.1%)	
W.C(cm)	108.35±14.42	105±13.8	93±13	0.048
Male				
<102 (cm)	11(12.9%)	16(26.7%)	35(38.9%)	
≥102 (cm)	23(27.1%)	20(33.3%)	16(17.8%)	0.001
Female				
<88 (cm)	5(5.9%)	2(3.3%)	24(26.7%)	
≥88 (cm)	46(54.1%)	22(36.7%)	15(16.6%)	<0.0001

BMI, body mass index; WC: waist circumferences. Significant level <0.05.

The biochemical analysis of the studied groups is shown in Table 2. The mean ± SD of fasting serum glucose (mg/dl), HbA1c (%), insulin(μIU/mL), HOMA-IR in type 2 diabetic patients and prediabetic individuals were significantly greater than control individuals. Similarly, lipid profile, apolipoprotein A and apolipoprotein B were greater in type 2 diabetic patients and prediabetic individuals than the control individuals.

The study showed that the mean ±SD of lipoprotein (a) level and prevalence rate of elevated lipoprotein (a) in type 2 diabetic patients (60.43±13.19 mg/dl, 69, 81.1%) and prediabetic individuals (42.53±11.65 mg/dl, 10, 16.7%) were greater than the healthy control individuals (27.3±11.16 mg/dl, 2, 2.2%) with statistically significant difference (P<0.0001).

Table 2 Biochemical parameters in type 2 diabetic patients, prediabetes and control individuals

Character	Type 2 diabetes n=85	Prediabetes n=60	Control n=90	P value
	Mean ± SD	Mean ± SD	Mean ± SD	
Fasting serum glucose (mg/dl)	173.10±52.31	101.08±7.59	85±11	<0.0001
Cholesterol (mg/dl)	160.25±87.23	153.07±43.13	126.04±33.73	<0.0001
Triglyceride (mg/dl)	153.73±86.76	115.30±65.05	94.16±41.52	<0.0001
HDL-C (mg/dl)	48.50±17.78	54.23±18.35	50.07±9.62	0.0182
LDL-C (mg/dl)	86.37±43.07	72.48±37.13	53.28±28.32	<0.0001
HbA1c (%)	8.36±1.87	6.01±0.22	4.9±0.5	<0.0001
Lipoprotein (a) (mg/dl)	60.43±13.19	42.53±11.65	27.3±11.16	<0.0001
Lipoprotein (a) ≥50 (mg/dl)	69(81.1%)	10(16.7%)	2(2.2%)	<0.0001
ApoA (mg/dl)	200.57±72.28	133.8±62.68	117.9±35.81	<0.0001
ApoB (mg/dl)	153.3±89.34	107.3±34.64	103±44	<0.0001
Insulin (µIU/mL)	15.17±11.04	14.48±8.38	12.33±3.75	<0.0001
HOMA-IR	6.78±6.46	3.81±2.39	2.56±0.81	<0.0001
One way ANOVA was performed for statistical analysis.				

HDL-C, high density lipoprotein-cholesterol; LDL-C, low density lipoprotein-cholesterol; HbA1c, Hemoglobin A1C; ApoA, Apolipoprotein A; ApoB, Apolipoprotein B; HOMA-IR, homeostatic model assessment of insulin resistance. Significant level <0.05.

The association of atherogenic indices between patients with type 2 diabetes mellitus, prediabetic and individuals of control group were shown in Table 3. There was a statistically significant difference between mean ± SD of atherogenic indices among studied groups. Type 2 diabetic patients and prediabetic individuals showed a higher mean ± SD of atherogenic indices than control individuals.

Table 3 Atherogenic indices in type 2 diabetic patients, prediabetes and control individuals

Atherogenic indices	Type 2 diabetes n=85	Prediabetes n=60	Control n=90	P value
	Mean ± SD	Mean ± SD	Mean ± SD	
LDL-C/HDL-C	2.08±1.40	1.57±1.01	1.2±0.76	0.0237
Cholesterol/HDL-C	3.78±1.57	3.05±1.06	2.6±0.88	0.0004
Triglyceride/HDL-C	3.46±2.05	2.396±1.92	2.02±1.15	<0.0001
non-HDL-C (mg/dl)	117.12±46.67	95.27±42.63	71.94±30.02	<0.0001
ApoB/ApoA	0.93±1.18	0.81±0.51	0.74±0.49	<0.0001

LDL-C, low density lipoprotein-cholesterol; HDL-C, high density lipoprotein-cholesterol; ApoB, apolipoprotein B; ApoA, apolipoprotein A. significant level<0.05.

The association of abnormal level of biochemical variables with mean ±SD of lipoprotein (a) is shown in Table 4. The study showed that mean level of lipoprotein (a) was statistically significant among type 2 diabetic patients with poor glycemic control, HbA1c ≥6.5%. The mean level of lipoprotein (a) was higher in relation to all abnormal parameters with type 2 diabetic patients and it was statistically insignificant.

Mean level of lipoprotein (a) was higher in relation to the abnormal levels of all parameters of prediabetic individuals and it was statistically significant with HDL-C in males (P=0.003) and with Apo A in females (P=0.007).

Table 4 Association of Lipoprotein (a) with abnormal biochemical parameters in T2DM, prediabetes and control individuals

Character	Lipoprotein (a) in Type 2 diabetes n=85		Lipoprotein (a) in prediabetes n=60		Lipoprotein (a) in Control n=90	
	Mean ± SD	P value	Mean ± SD	P value	Mean ± SD	P value
Gender						
Male	60.03±13.42	0.856	40.74±8.93	0.147	27.31±10.51	0.990
Female	61.05±14.38		45.20±14.62		27.28±11.59	
FSG < 100 (mg/dl)		na	40.36±9.21	0.490	27.29±10.96	na

≥ 100 (mg/dl)	60.64±13.94		42.21±11.65			
Cholesterol < 200 (mg/dl) ≥ 200 (mg/dl)	59.09±9.12 61.17±14.97	0.575	41.78±10.21 45.23±16.02	0.349	26.50±10.46 44.36±7.93	<0.0001
Triglyceride < 150 (mg/dl) ≥ 150 (mg/dl)	59.72±8.89 61.35±15.02	0.283	41.71±10.26 45.48±10.26	0.306	27.06±11.19 29.33±9.18	0.840
HDL-C Male > 40 (mg/dl) ≤ 40 (mg/dl) Female > 50 (mg/dl) ≤ 50 (mg/dl)	59.68±10.19 61.14±15.37 60.99±15.87 62.04±9.25	0.746 0.529	37.87±7.00 45.90±9.89 44.46±12.49 46.24±17.85	0.003 0.633	26.87±10.42 28.26±11.18 26.07±11.89 27.69±11.67	0.557 0.241
LDL-C < 130 (mg/dl) ≥ 130 (mg/dl)	55.94±8.19 61.17±13.74	0.206	39.37±8.46 43.57±12.43	0.797	26.45±13.96 27.29±10.86	0.791
HbA1c < 6.5 % ≥ 6.5 %	51.86±8.61 61.57±13.32	0.028	42.53±11.65	na	27.29±10.96	na
ApoA Male: < 160 (mg/dl) ≥ 160 (mg/dl) Female < 175 (mg/dl) ≥ 175 (mg/dl)	64.30±18.1 58.10±6.51 58.99±10.43 61.47±15.83	0.181 0.052	40.70±10.37 40.99±8.53 40.81±10.72 58.40±17.71	0.787 0.007	25.00±9.46 34.79±10.39 26.79±11.71 36.23±0.84	0.004 0.268
ApoB < 130 (mg/dl) ≥ 130 (mg/dl)	59.98±12.79 61.04±13.87	0.715	42.02±11.09 45.41±14.87	0.425	27.68±10.94 24.80±11.22	0.400
Insulin 2-20 (µIU/mL) ≥ 20 (µIU/mL)	59.53±13.28 62.48±13.00	0.346	43.05±9.19 42.64±12.00	0.899	27.15±11.02 33.57±11.02	0.416
HOMA-IR < 3.0 ≥ 3.0	59.23±7.93 62.72±19.74	0.246	40.88±9.42 43.78±13.09	0.345	26.96±11.62 27.96±9.67	0.690

FSG, fasting serum glucose; HDL-C, high density lipoprotein-cholesterol; LDL-C, low density lipoprotein-cholesterol; HbA1c, Hemoglobin A1C; ApoA, Apolipoprotein A; ApoB, Apolipoprotein B; HOMA-IR, homeostatic model assessment of insulin resistance. Significant level <0.05.

The relation between mean ±SD of lipoprotein (a) and abnormal atherogenic indices is shown in Table 5. The mean levels of lipoprotein (a) were insignificantly higher in relation to all abnormal levels of atherogenic indices in type 2 diabetic patients. In prediabetic individuals, the mean level of lipoprotein (a) was statistically significant with ApoB/ApoA ratio in females (P=0.001). Moreover, the mean level of lipoprotein (a) was higher in relation to the abnormal levels of atherogenic indices in prediabetic individuals and there was a statistically insignificant difference.

Table 5 Assosiation of Lipoprotein (a) with atherogenic indices in type 2 diabetic patients, prediabetes and control individuals

Atherogenic indices	Lipoprotein (a) in type 2 diabetes n=85		Lipoprotein (a) in prediabetes n=60		Lipoprotein (a) in Control n=90	
	Mean ± SD	P value	Mean ± SD	P value	Mean ± SD	P value
LDL-C/HDL-C < 2.5 ≥ 2.5	60.29±13.93 60.81±11.21	0.875	42.79±8.13 42.47±12.29	0.940	26.78±10.99 36.07±6.17	0.065
Cholesterol/HDL-C < 4.5 ≥ 4.5	58.39±10.89 60.98±13.77	0.462	42.21±12.01 44.29±9.74	0.627	26.78±10.88 38.36±6.47	0.038
Triglyceride/HDL-c < 3.0 ≥ 3.0	58.81±10.76 61.81±14.28	0.300	41.39 ±8.23 42.73±12.20	0.755	26.79±11.21 30.89±8.66	0.248
non-HDL-C < 130 (mg/dl) ≥ 130 (mg/dl)	57.59±9.00 61.91±14.77	0.154	40.64±10.76 42.99±11.91	0.535	27.05±10.93 38.36±7.92	0.150
ApoB/ApoA Male < 0.9 ≥ 0.9 Female: < 0.8 ≥ 0.8	55.44±10.34 61.55±11.92 56.38±8.81 62.42±15.68	0.202 0.169	41.44±11.0 40.03±6.47 37.79±15.03 55.58±15.03	0.643 0.001	23.85±9.36 29.93±10.8 26.41±12.33 27.88±11.28	0.041 0.703i

LDL-C, low density lipoprotein-cholesterol; HDL-C, high density lipoprotein-cholesterol; ApoB, apolipoprotein B; ApoA, apolipoprotein A. significant level<0.05.

5. DISCUSSION

In the current study, the results showed a non-significant elevation in the BMI and a significant increase in the waist circumference in type 2 diabetic patients and prediabetic individuals compared to healthy control group. Our results agreed with the study that showed a higher body mass index and waist circumference among patients with type 2 diabetes mellitus and prediabetic individuals (Haghighatdoost, 2017; Li, 2011). This relationship can be explained by aging process and accumulation of body fat, both characterized pathophysiologically by chronic inflammation leading to dysfunction of β pancreatic cell and insulin resistance (Ponti, 2020; Cerf, 2013).

Changes in lipoprotein (a) levels among type 2 diabetic patients and prediabetic individuals remain controversial as inconsistent results have been reported by many studies regarding the connection between type 2 diabetes mellitus, prediabetes and lipoprotein (a) levels (Jin, 2019; Daniel, 2011). In the current study, a significantly higher mean level of lipoprotein (a) and high prevalence rate of high level of lipoprotein (a) were observed in type 2 diabetic patients (60.43±1319 mg/dl, 69, 81.1%) and prediabetic individuals (42.53±11.65 mg/dl, 10, 16.7%) compared to healthy control individuals (27.3±11.16 mg/dl, 2, 2.2%). These results were consistent with a study condcuted by Saeed A et al. which showed that the levels of lipoprotein (a) were higher in type 2 diabetic patients and prediabetic individuals (Saeed, 2019). Also, our results were consistent with the research done by Joseph et al. which indicated that type 2 diabetes mellitus is linked to higher levels of certain cardiovascular risk markers, such as lipoprotein (a) (Joseph, 2016). Our results were inconsistent with the study carried out by Lin Ding et al. and Lamina et al. who discovered a negative significant relationship between lipoprotein (a) levels and type 2 diabetes mellitus (Ding, 2015; Lamina & Ward, 2022). The high level of lipoprotein (a) in type 2 diabetic patients and prediabetic individuals can be due to many factors such as lipoprotein (a) clearance from the serum which is reduced because of glycation of its apolipoproteins, peripheral resistance to insulin action in the presence of prolonged hyperinsulinemia, an increase in the rate of synthesis of lipoprotein (a) than its catabolic rate and a decrease rate of catabolism of LDL-C (Habib, 2013; Karmakar, 2020; Bhowmik, 2018).

In the current study, the relation between mean level of lipoprotein (a), total cholesterol, triglyceride and LDL-C among type 2 diabetic patients and prediabetic individuals were insignificantly positive, as there was a higher mean level of lipoprotein (a) among diabetic patients and prediabetic individuals with hypercholesterolemia and hypertriglyceridemia . This positive correlation may be related to lipoprotein (a) structure as it is composed of cholesterol and LDL. Our results were consistent with a previous study done in China by Wen Dai, et al. and Peela et al. in Libya (Dai, 2018; Peela, 2018) and this was inconsistent with a study done by Premkumar K. and Candido AP., et al. in India and Brazil (Premkumar, 2006; Cândido, 2007). There was an inverse relationship between levels of lipoprotein (a) and HDL-C in type 2 diabetic patients and prediabetic individuals; as increasing of lipoprotein (a) causes decreases in the levels of HDL-C, as indicated in previous studies (Karmakar, 2020; Málek, 2015).

Our results showed a positive but insignificant relationship between lipoprotein (a) levels and atherogenic indices in type 2 diabetic patients and prediabetic individuals compared to healthy controls, which is consistent with the previous study done in Sudan by Mohieldein, A. H., et al. and Yen et al. (Mohieldein, 2014; Yen, 2021). In the present study, the mean level of lipoprotein (a) was positively correlated with insulin resistance as the mean of lipoprotein (a) level was higher in type 2 diabetic patients and prediabetic individuals with HOMA-IR more than 3.0 . This contradicted a prior Spanish study which found a negative relationship between Lipoprotein (a) and HOMA-IR in diabetic individuals (Boronat, 2012; Vaverková, 2017).

The relationship between changes in lipoprotein (a) levels and diabetic glycemic control is still disputed . The majority of the research on individuals with type 2 diabetes mellitus have not found any relationship between lipoprotein (a) levels and glycemic control (Bener, 2007; Daghash M, 2007). Our results showed that mean level of lipoprotein (a) significantly increased with HbA1c more than 6.5% (poor diabetic control), this was consistent with a prior study done by Yan Zhang et al. (Zhang, 2020).

In the present study, the lipid profile was significantly abnormal in type 2 diabetic patients and prediabetic individuals compared to healthy control groups. The mean level of serum cholesterol, triglyceride and LDL-C were increased and mean HDL-C level was decreased in type 2 diabetic patients and prediabetic individuals . These results were consistent with a previous study done by Daniel, M. J. and Ozder (Daniel, 2011; Ozder, 2014). Due to insulin resistance or insufficiency impacting important rate limiting enzymes and pathways in lipid metabolism, lipid abnormalities are prevalent among diabetic patients (Mirhosseini, 2018; Ormazabal, 2018).

Atherogenic indices are regarded as specific markers for cardiovascular risk development (Ma, 2020; Bo, 2018). In the present study, we found significantly higher levels of the atherogenic indices in type 2 diabetic patients and prediabetic individuals compared with healthy control groups. Prolonged hyperglycemia and insulin resistance in diabetes mellitus enhance lipogenesis, raise triglyceride concentrations, and reduce HDL-C (Mirhosseini, 2018; Su, 2017).

Our study showed that the mean levels of apoB/ApoA ratio increased in type 2 diabetic patients and prediabetic individuals compared to healthy control individuals, our results were consistent with the previous study showed that apoB/apoA ratio increased in diabetic patients. Apolipoprotein A and Apolipoprotein B controlled and stabilzed the production and metabolism of lipoprotein particles, therefore; the balance of atherogenic and atheroprotective particles is reflected by ApoB/ApoA ratio, so the higher the level, the greater tendency of cholesterol accumulation, and hence a greater risk of cardiovascular disease will be developmed (Zheng, 2017; Gao, 2021).

Type 2 diabetic patients and prediabetic individuals are more risky of developing cardiovascular disease due to presence of high mean level of lipoprotein (a), atherogenic indices and abnormal levels of lipid profile. Other studies showed that the high lipoprotein (a) level, atherogenic indices and abnormal levels of lipid profile were a risk factor for developing cardiovascular disease (Saeed, 2019; Bhowmik, 2018; Al-Shaer, 2021).

6. CONCLUSION

The high level of lipoprotein (a) and high prevalence rate of abnormal high lipoprotein (a) were found in type 2 diabetes mellites and prediabetes. The presence of a high mean level of lipoprotein (a), lipid profile and atherogenic indices among type 2 diabetes mellitus and prediabetes will improve the chance of developing cardiovascular disease, therefore; early diagnosis and management of type 2 diabetes and prediabetes are crucial as it may associate with decreased levels of lipoprotein (a) and lipid profile, thus decreasing the risk of development of cardiovascular diseases.

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