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Original article

Correlation of Lipid Profile and BMI with Fasting Blood Glucose

Seham Eljali*, Abdulwahb Al-deib, Mohammed Aljorni, Malek Raghibe

Department of Medical Laboratory Sciences, Faculty of Medical Technology, University of Tripoli, Tripoli, Libya

***Corresponding Email**. s.eljali@edu.ly*

ABSTRACT

The prevalence in Libya of overweight people has more than tripled from 19.5% in 1984 to 63.5% in 2009, while the rate of obesity has more than doubled over the past three decades leading to a much higher incidence of Type 2 diabetes T2DM. This makes investigation of links between BMI and lipid profiles in Libyan T2DM patients of vital importance. This study was conducted to determine the cor-relation between body mass index (BMI) and lipid profiles in patients with T2DM attending outpatient clinics in the Diabetes and Endocrinology Centre (Ibn Al-Nafees Hospital) Tripoli, Libya. The second objective was to compare BMI, FBS and lipid profiles between T2DM patients and a control group. The study was carried out during the period of June and July 2024 included 122 T2DM patients and 55 healthy subjects. The subject's serum was analysed for total cholesterol (TC), triglyceride (TG), high density lipoprotein cholesterol (HDL-C) and low-density lipoprotein cholesterol (LDL-C). The possible correlation of BMI with lipid values were analysed. The Pearson's co-efficient between the BMI and the lipid parameters did not show any significant correlation in T2DM patients. Comparisons of various parameters between T2DM patients and the control group showed that the mean values of fasting glucose levels, weight, BMI, TG, HDL-C and LDL-C were significantly higher in the T2DM group than the control group. There was no correlation found between BMI and lipid profiles in T2DM patients. Type 2 diabetic patients have significantly higher mean weight, BMI, FBS, TG, HDL-C and LDL-C compared with healthy controls

Keywords. Type 2 Diabetes, Body Mass Index, Lipid Profile.

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لقد تضاعف انتشار الأشخاص الذين يعانون من زيادة الوزن في ليبيا أكثر من ثلاثة أضعاف من 19.5٪ في عام 1984 إلى 63.5٪ في عام 2009، في حين تضاعف معدل السمنة بأكثر من الضعف على مدى العقود الثلاثة الماضية مما أدى إلى ارتفاع معدل الإصابة بمرض السكري من النوع 2 .T2DM وهذا يجعل التحقيق في الروابط بين مؤشر كتلة الجسم وملفات الدهون لدى مرضى السكري من النوع 2 الليبيين ذا أهمية حيوية. أجريت هذه الدراسة لتحديد العلاقة بين مؤشر كتلة الجسم وملفات الدهون لدى مرضى السكري من النوع 2 الذين يرتادون العيادات الخارجية في مركز السكري والغدد الصماء (مستشفى ابن النفيس) طرابلس، ليبيا. وكان الهدف الثاني هو مقارنة مؤشر كتلة الجسم وملفات الدهون بين مرضى السكري من النوع 2 ومجموعة ضابطة. أجريت الدراسة خلال الفترة من يونيو ويوليو 2024 وشملت 122 مريضًا بمرض السكري من النوع 2 و 55 شخصًا سليمًا. تم تحليل مصل المريض من حيث الكوليسترول الكلي (TC) والدهون الثلاثية (TG) وكوليسترول البروتين الدهني عالي الكثافة (HDL-C) وكوليسترول البروتين الدهني منخفض الكثافة .(LDL-C) وتم تحليل الارتباط المحتمل بين مؤشر كتلة الجسم وقيم الدهون. ولم يظهر معامل بيرسون بين مؤشر كتلة الجسم ومعايير الدهون أي ارتباط مهم لدى مرضى السكري من النوع 2. وأظهرت المقارنات بين المعايير المختلفة بين مرضى السكري من النوع 2 ومجموعة التحكم أن متوسط قيم مستويات الجلوكوز في الصيام والوزن ومؤشر كتلة الجسم والكوليسترول الكلي والكوليسترول الحميد والكوليسترول الضار كانت أعلى بشكل ملحوظ في مجموعة السكري من النوع 2 مقارنة بالمجموعة الضابطة. ولم يتم العثور على أي ارتباط بين مؤشر كتلة الجسم وملامح الدهون لدى مرضى السكري من النوع 2. ويتمتع مرضى السكري من النوع 2 بمتوسط وزن ومؤشر كتلة الجسم ونسبة الدهون في الدم ونسبة الدهون الثلاثية والكوليسترول الحميد والكوليسترول الضار أعلى بشكل ملحوظ مقارنة بالضوابط الصحية

INTRODUCTION

Type 2 diabetes mellitus (T2DM) is becoming more common worldwide and is found to be increasing in almost all areas [1]. Globally, 463 million people had this chronic disease in 2019 and this figure is predicted to rise to over 690 million by 2045 [2]. It is important to note that microvascular conditions including diabetic kidney disease, retinopathy, and peripheral neuropathy, as well as macrovascular issues like coronary heart disease and stroke, are complications often experienced by T2DM patients [3].The onset of T2DM and its associated health complications lower people's quality of life and place a heavy financial and social burden on society [4].The International Diabetes Federation (IDF) Diabetes Atlas [5] indicates that in 2021 (for those aged 20-79) 10.5% of the global adult population had diabetes. The prevalence of diabetes in Libya in 2021, according to the IDF Diabetes Atlas, for those aged 20-79 is 9%. These high figures make further studies of this disease necessary in order to understand and treat diabetes effectively [5].

Obesity, ethnicity, sedentary lifestyles, sex, family history, hypertension, smoking, and alcohol intake are frequently linked to T2DM [6]. Nonetheless, a wealth of data from ep-idemiological, experimental, and intervention research indicates that, among all risk factors, obesity is a major risk factor for developing T2DM. In Libya in the twenty-first century obesity has reached epidemic proportions. The country continues to experience a steady increase in obesity in all age groups, a rise also observed in other emerging nations [7]. The prevalence in Libya of overweight people (BMI ≥25 kg/m2) has more than tripled from 19.5% in 1984 to 63.5% in 2009, while the rate of obesity (BMI ≥30 kg/m2) has more than doubled over the past three decades [8,9].

Research on obesity has shown it increases the risk of T2DM by causing insulin resistance (IR), and lipid metabolism disorders. Such functional disorders in those who are obese release large amounts of free fatty acids, reactive oxygen species, and pro-inflammatory cytokines from their adipocytes that can contribute to IR early on and also β cell dysfunction [10,11]. Insulin dependent tissues, in the IR metabolic state, experience a reduced sensitivity to the action of insulin that results in inefficient conversion of blood sugar into energy and an increase in blood sugar [12]. Prolonged insulin resistance (IR) may result in a decrease in the functioning of pancreatic islets β cells, and a subsequent decrease in insulin secretion which could potentially lead to diabetes [13,14].

Furthermore, obesity may have an impact on the metabolism of fats and this is frequently coupled with lipid abnormalities such hypertriglyceridemia and high-density lipoprotein cholesterol (HDL-C), which worsen the health outcomes in terms of IR [15]. The body produces more lipid metabolites when the lipid index rises, elevating the risk of diabetes, hyperlipidaemia, and hyperuricemia [16,17]. The prevalence of T2DM has been observed to rise in correlation with the global increase in the occurrence of obesity [18]. Studies have revealed that roughly 90% of T2DM patients develop diabetes largely as a result of their excess weight [19–21].

Research has demonstrated an inverse correlation between body mass index (BMI) and HDL-C and direct correlation between increased BMI and elevated total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), and triglycerides (TG). It has been suggested that the relationship between BMI and lipoprotein levels, particularly LDL-C, is a significant risk factor for cardiovascular illnesses in those with obesity. However, there is insufficient data from the small number of obese and severely obese subjects in these trials, to date, to make any certain assumptions on the expected lipid parameters in this population [22]. Recent observational studies have confirmed a correlation between BMI and TG or HDL-C in obese patients, apart from LDL-C levels. These findings suggest an "obesity paradox" in that LDL-C levels may increase or decrease with exceptionally high BMI levels [23,24]. Given these observations, it was considered important to examine the link between body mass index and lipid profiles in people with T2DM in Libya.

METHODS

Study setting

The study was carried out during the period of June and July 2024 included 122 T2DM patients who were selected from adult diabetic patients attending outpatient clinics in the Diabetes & Endocrinology Centre (Ibn Al-Nafees Hospital) Tripoli, Libya. The control group included 55 healthy subjects. Selection of both patients and healthy controls by a random sampling technique was undertaken. The control group had blood glucose measurements taken to verify no evidence of diabetes was present. The survey questionnaire covered a range of topics including ag e and gender. After the questionnaire had been completed participants had to provide measurements such as height (to nearest 0.1 cm) without shoes. Body weight was measured with electronic weighing scales (to the nearest 0.01 kg). Height and weight were then used to determine the Body mass index (BMI) (weight kg/height m2).

Sample collection and blood testing

5 ml of venous blood was drawn from each volunteer in this study, and about 3 ml of blood was placed in a white tube (clot activator). The remaining 2 ml of blood was placed in a sodium fluoride tube to measure fasting blood glucose level. Following this they were transferred to Al-Rahma laboratory where an automatic device BK-280 – BIOBASE was used to measure the levels of cholesterol, triglycerides, HDL, LDL and fasting blood sugar for all the samples of controls and patients.

Data Analysis

The statistical package SPSS version 26.0 (SPSS, IBM® SPSS® Statistics 26) was used for statistical analysis. Significant difference was considered at $P < 0.05$.

RESULTS

A total of 122 T2DM Libyan patients, attending the Diabetes & Endocrinology Centre in Tripoli, Libya, participated in this study. Of these 59 (48%) were males and 63 (52%) were females. Table 1 shows that most of the parameters investigated (mean of age, BMI, TC, HDL-C LDL-C) differed significantly between male and female T2DM patients. Con-versely, both mean FBS and TG levels did not show significant statistical difference between genders. Male patients in the group had a higher average age (59.22 ± 13.68 years) com-pared to female patients (53.67± 11.21years), with p-value of 0.015. Female patients had higher average BMI (31.80± 5.91 kg/ m2) compared to males (27.39± 5.27kg/m2) with statistically significant difference (p-value= 0.001). Females had a higher average TC level (179.71± 50.67mg/dl) compared to males (141.54± 32.69 mg/dl), with a p-value of 0.001. Females had a higher average HDL-C level (56.57± 27.92mg/dl) compared to males (44.90± 16.74mg/dl), with a p-value of 0.006. Females had a higher average LDL-C level (92.03± 47.81mg/dl) compared to males (68.34± 28.80 mg/dl), with a p-value of 0.001. While the rest of the parameters (FBS and TG) did not show significant difference in a gender wise manner with p value=0.862 and 0.781 respectively.

Table 1. Comparison of age, BMI, and lipid profiles between male and female T2DM patients.

Parameters	Males (N=59)			Females (N=63)			p-value
	Mean	SD	Range	Mean	SD	Range	
Age (years)	59.22	13.68	60.00	53.67	11.21	57.00	0.015
BMI (kg/ m2)	27.39	5.27	22.00	31.80	5.91	31.90	0.001
FBS (mg/dl)	191.32	99.72	477.00	194.59	106.95	697.00	0.862
TC (mg/dl)	141.54	32.69	148.00	179.71	50.67	256.00	0.001
TG (mg/dl)	153.05	93.77	485.00	157.65	88.81	435.00	0.781
HDL-C (mg/dl)	44.90	16.74	106.00	56.57	27.92	180.00	0.006
LDL-C (mg/dl)	68.34	28.80	124.00	92.03	47.81	233.00	0.001

BMI= Body Mass Index, FBS, fasting blood sugar.TC= Cholesterol, TG= Triglyceride, LDL-C= Low Density Lipoprotein Cholesterol, HDL-C= High Density Lipoprotein cholesterol.

The Pearson's co-efficient between the BMI and the lipid parameters did not show any significant correlation as shown in Table 2. TC (r=0.001, p=0.989), TG (r=0.057, p=0.536), HDL-C (r=0.108, p=0.236) and LDL-C (r=-0.074, p=0.423). There was a statistically sig-nificant correlation found between HDL-C levels and Fasting sugar levels (r=0.25, p= 0.005) and also between HDL-C levels and TC levels (r=0.44, p=0.001). There was one other significant correlation found between LDL-C levels and TC levels (r=0.76, p=0.001).

Table 2. Correlation analysis between BMI and lipid parameters

Tests		BMI	FBS	TC	TG	HDL-C
FBS (mg/dl)	r	-0.101	-	-	-	-
	p	0.269	-	-	-	-
TC (mg/dl)	r	0.001	0.160	-	-	-
	p	0.989	0.078	-	-	-
TG (mg/dl)	r	0.057	0.142	0.18*	-	-
	p	0.536	0.119	0.047	-	-
HDL-C (mg/dl)	r	0.108	0.25**	0.44**	0.006	-
	p	0.236	0.005	0.001	0.945	-
LDL-C (mg/dl)	r	-0.074	-0.018	0.76**	-0.150	-0.094
	p	0.423	0.844	0.001	0.100	0.308

Table 3. Comparison of age, Fasting Sugar, BMI and lipid profiles between male and female T2DM patients.

Parameters	Normal (N=29)			Overweight (N=36)			Obese (N=57)			p-value
	Mean	SD	SE	Mean	SD	SE	Mean	SD	SE	
Age (years)	51.52	16.26	3.02	59.58	13.43	2.24	56.77	9.25	1.23	0.036*
FBS (mg/dl)	206.86	100.37	18.64	203.86	93.30	15.55	179.11	110.08	14.58	0.379
TC (mg/dl)	158.28	49.64	9.22	164.72	46.43	7.74	160.58	46.36	6.14	0.852
TG (mg/dl)	135.41	80.87	15.02	169.69	85.49	14.25	156.60	98.34	13.03	0.319
HDL-C (mg/dl)	48.45	30.18	5.61	48.19	16.47	2.75	53.91	24.20	3.20	0.436
LDL-C (mg/dl)	82.67	44.60	8.28	82.98	40.10	6.78	78.25	41.16	5.45	0.833

Table 4. Comparison of parameters between T2DM patients and control group.

Parameters	T2DM patients (N=122)			Controls (N=55)			p-value
	Mean	SD	Range	Mean	SD	Range	
Age (years)	56.35	12.72	61.00	48.69	17.79	48.69	0.001
Standing Height (m)	1.65	0.09	0.47	1.64	0.10	1.64	0.368
Weight (kg)	80.92	16.64	104.00	73.22	14.17	73.22	0.003
BMI (kg/ m2)	29.67	6.01	33.80	27.20	4.60	27.20	0.007
FBS (mg/dl)	193.01	103.10	268.00	90.02	12.88	165.01	0.001
TC (mg/dl)	161.25	46.85	485.00	165.01	34.62	128.79	0.595
TG (mg/dl)	155.43	90.89	180.00	128.79	57.38	43.49	0.020
HDL-C (mg/dl)	50.92	23.84	233.00	43.49	10.02	96.04	0.004
LDL-C (mg/dl)	80.68	41.42	702.00	96.04	31.74	90.02	0.008

Patients were divided into three groups based on their body mass index (BMI); group one consisted of patients with normal BMI (18.5 – 24.9 kg/m2), group two of patients with overweight BMI (25- 29.9kg/m2) and group three were obese (≥ to 30 kg/m2). A large number of the Libyan T2DM patients 57 (47%) were obese, with a BMI of over 30kg/m2. Those who were overweight had higher values of TC (164.72±46.43), TG (169.69±85.49) and LDL-C (82.98±40.10) compared to those with either normal or obese BMI as shown in

Table 3. Obese patients were observed to have higher values of HDL-C (53.91±24.20) than the other two groups. However, the differences were not statistically significant. There was a significant difference found in the mean age between three BMI categories with p=0.036 those with overweight BMI having an older mean age than the other two groups.

Table 4 shows comparisons in various parameters between T2DM patients (122) and the control group (55). The mean values of fasting glucose levels, age, standing height, weight, BMI, FBS, TG, HDL and LDL were significantly higher in the T2DM group compared with the control group, whereas TC levels were significantly lower in T2DM patients compared to the control group. Statistically significant differences between the two groups were observed for all the parameters measured, except for Standing Height and TC levels. The p values for those parameters which were significant statistically were for age (0.001), weight (0.003), BMI (0.007), FBS (0.001), TG (0.02), HDL-C (0.004) and LDL-C (0.008).

DISCUSSION

Being overweight is one of the most prevalent lifestyle issues in today's world. Excessive weight or obesity is a major risk factor for the onset of numerous chronic conditions, in-cluding Type 2 diabetes. The health consequences of excessive body fat even if there is a very moderate increase in body weight are clear, from both scientific studies and data from life insurance companies [25]. However, being overweight and obese are severe issues that place an enormous and increasing costly strain on public resources. Overweight and obesity affect over 64% of the Libyan population, with the prevalence of obesity rising with age and being twice as high among Libyan women as males [26].

The mean values of BMI, FBS, TC, TG, HDL-C, and LDL-C were greater in female patients than in male patients, and the mean differences were statistically significant with the ex-ception of FBS and TG. Age, BMI, FBS, and lipid values differed according to gender. Similar results to these with LDL-C in showing clear differences between males and females were also found by other researchers [27]. Regarding the variations in HDL-C and LDL-C concentrations between men and women, a 2015 study by Ni et al. supports the present research results [28].

According to earlier research, diabetes changes the lipid makeup of different tissues [29]. Therefore, it is hypothesised that circulatory lipids are essential to the development of type 2 diabetes, not only through lipid abnormalities but also through changes in the hardness, composition, and structure of cellular membranes [29]. High levels of TG, TC, and LDL-C were found in diabetic individuals in a number of investigations; this was also the case for TG in the current investigation. However, another study conducted in Nigeria found con-versely that healthy individuals had greater TG levels compared to diabetic patients [30]. Impaired insulin secretion, which impacts the liver's apolipoprotein synthesis and controls the enzymatic activity of lipoprotein lipase (LpL) and cholesterol ester transport protein (CETP), is the primary cause of lipid abnormalities in people with type 2 diabetes. Fur-thermore, a lack of insulin lowers hepatic lipase activity, which means that a number of processes that produce biologically active LpL may be different in T2DM patients than in healthy individuals. In the current investigation, we found that T2DM patients' mean BMI values were statis-tically significantly higher than those of healthy subjects. Other studies have also found similar results linking high BMI levels to diabetic patients [31]. The current investigation found no relationship between the BMI and serum lipid profile levels in T2DM patients from Libya. A different result was found in a study carried out on 305 T2DM patients in Pesh-awar, Pakistan, which found substantial negative association between BMI and HDL-C and an insignificant link between BMI and LDL-C [27].

Contrary to the current research, a Saudi Arabian study found a negative link between BMI and HDL and a positive correlation between BMI and TC and LDL-C. Our results agreed only with the Saudi Arabian findings on TG where they reported no relationship between TG and BMI [32]. According to the current study, FBS showed a statistically significant cor-relation with HDL-C in T2DM patients. Conversely, other researchers [33] found FBS had statistically significant correlation with TG and LDL-C in T2DM patients. Limitation of this study is that the control sample size is small in comparison to the T2DM sample group and this might well reduce the accuracy of comparisons drawn between the two groups.

CONCLUSION

T2DM patients and healthy individuals differed statistically significantly in a few lipids profile levels. Additionally, the study found that diabetics had significantly higher BMI and FBS than healthy subjects. In T2DM patients there was a statistically significant correlation found between HDL-C levels and fasting glucose levels. Poor glycaemic management and unhealthy changes in lifestyle can cause this. This indicates that in order to stop and slow the disease's progression, T2DM patients need to be educated about adequate glycaemic con-trol and have routine follow-ups. Even for healthy controls, periodic medical examinations and suitable lifestyle modifications can help achieve weight loss objectives, control dyslipidaemia, and result in lower incidents of cardiovascular disease. Therefore, future multi-centre prospective studies with a bigger sample size might be beneficial both in terms of accuracy of results and impact of T2DM educational interventions.

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