

Determination and Evaluation of Serum Lipid Profile, Creatinine and Glycated hemoglobin (HbA_{1c} %) in Sudanese Patients with Type 2 Diabetes Mellitus Associated with Obesity

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Abstract

A cross sectional study conducted during the period from February 2011 to April 2012 to determine and to evaluate the serum levels lipid profile, creatinine and HbA_{1c} in Sudanese patients with type 2 diabetes mellitus associated with obesity. Two hundred Sudanese with type 2 diabetes mellitus associated with obesity were selected as a test group from Khartoum, Omdurman and Khartoum North hospitals in Khartoum state, Sudan. The test group was compared with a control group, which included 100 apparently healthy volunteers. Blood specimens were collected from both groups, and the serum levels of lipid profile (total cholesterol, triglycerides, high density lipoprotein cholesterol (HDL_C) and low-density lipoprotein cholesterol (LDL_C), in addition to fasting plasma glucose (FPG) and creatinine and glycated hemoglobin (HbA_{1c}) were determined. Age and gender of the test group were matched with the control group. The serum levels of plasma glucose, total cholesterol, HDL_C, LDL_C, triglycerides, creatinine and HbA_{1c} were measured using spectrophotometer methods. Statistical Package for Social Science (SPSS version 11.5) computer software was used for data analysis. The results of this study indicated significantly raised means of the serum levels of total cholesterol, LDL_C, triglycerides and creatinine of the test group when compared with the control group, whereas the mean of the serum levels of HDL_C of the test group showed a significant reduction when compared with the control group. The results of this study also indicates a significant elevation of the means of the serum levels of total cholesterol, LDL_C, triglycerides and creatinine among diabetic patients with ischemic heart disease when compared with those without ischemic heart disease, whereas the mean of the serum levels of HDL_C among diabetic patients with ischemic heart disease shows a significant reduction when compared with those without ischemic heart disease. The means of the serum levels of total cholesterol, LDL_C, triglycerides and creatinine among diabetic patients with hypertension or having renal insufficiency were significantly raised when compared with those without these diseases. Whereas the means of the serum levels of HDL_C among diabetic patients with hypertension or having renal insufficiency were found to be significantly decreased when compared with those without these diseases. The results of the current study shows a significant moderate positive correlation between the duration of diabetes (in years) and the serum levels of total cholesterol, LDL_C, triglycerides and creatinine, whereas there is a significant moderate negative correlation between the duration of diabetes (in years) and the serum levels of HDL_C, and shows a significant strong positive correlation between the duration of diabetes and the serum levels of creatinine. This study shows insignificant weak positive correlations between HbA_{1c} and the serum levels of total cholesterol, LDL_C, triglycerides and creatinine and insignificant weak negative correlation between HbA_{1c} and the serum levels of HDL_C. **Conclusion:** The serum levels of total cholesterol, triglycerides and LDL are significantly raised in obese – diabetic patients, whereas the levels of HDL are significantly reduced, so regular measurements of the serum levels of total cholesterol, LDL_C, triglycerides and creatinine and HbA_{1c} can be used as prognostic markers for follow up of obese - diabetic patients especially in those with complications such as hypertension, ischemic heart disease and renal insufficiency.

Keywords: Determination and Evaluation, Glycated hemoglobin, Blood specimens.

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INTRODUCTION

Obesity and diabetes are reaching epidemic proportions in developed countries in the 21st century

while, at the same time, they are also becoming disturbingly more prevalent in developing countries. Diabetes, the most common non-communicable disease,

is having an increasing impact on rates of morbidity and mortality in Sudan. The spread of sedentary lifestyles and adoption of western dietary habits – high in refined carbohydrates and fat– are driving an increase in the number of people with obesity-related type 2 diabetes [1].

Diabetes mellitus is a group of metabolic disorders of carbohydrate metabolism in which glucose is underutilized, producing hyperglycemia. Some individual may experience acute life – threatening hyperglycemic episodes, such as ketoacidosis or hyperosmolar coma [2].

The new classification system identifies four types of diabetes mellitus: type 1, type 2, other specific types and gestational diabetes. Each of the type of diabetes mellitus identified extends across a clinical continuum of hyperglycemia and insulin requirements [3].

Patients with Type 2 diabetes are frequently affected by atherosclerotic vascular disease. These patients often have abnormalities of both quantity and quality of lipoproteins that, among other factors, might be responsible for the increased incidence of vascular complications. Several studies were conducted to find out the lipid abnormalities in diabetes mellitus and to ascertain the effect of anti-diabetic treatment on these abnormalities [4].

The prevalence of type 2 diabetes has escalated in recent years, mainly as a result of changes in lifestyle and increasing obesity. Death is usually due to cardiovascular disease, especially if nephropathy is already present in type 2 diabetes, hypertension is frequent co-morbidity, often being present when diabetes is diagnosed [5].

Data about the prevalence of diabetes epidemic in Sudan is limited. The most recent data come from a small-scale study that was carried out in 1996. The results of the study indicated a prevalence of 3.4% [4]. Overweight and obesity have reached epidemic proportions globally along with an adoption of a westernized lifestyle characterized by a combination of excessive food intake and inadequate physical activity. In the United States, the prevalence of obesity doubled during the past two decades, and currently 30% of the US adult population is classified as obese. An additional 35% of US adults are overweight but not obese. Children and adolescents are not immune to the epidemic. Among US children and adolescents, 16% are overweight and an additional 15% are at risk of overweight. It has been estimated that the total number of adults with diabetes (mainly type 2 diabetes) will approximately double between 2000 and 2030, from 171 million to 366 million [6].

Obesity represents a major component of the metabolic syndrome and has a significant association with insulin resistance. Clearly, most individuals with the metabolic syndrome are overweight or frankly obese, and most people with insulin resistance have truncal obesity. It is this truncal, central, visceral, or predominately upper body distribution of body fat that has a stronger association for cardiovascular disease than only being overweight or having an increased body mass index (BMI) [7].

Although skeletal muscle is one of the major target organs of insulin, to our knowledge, no prospective study has investigated the association between total skeletal muscle mass and type 2 diabetes. The level of serum creatinine is used as a marker of renal function; it is elevated in patients with renal impairment. One of the serious complications of diabetes mellitus is diabetic nephropathy which is characterized by progressive deterioration of renal function that associated with reduction of creatinine clearance [8]. Glycated hemoglobin (glycosylated hemoglobin, hemoglobin A_{1c}), is a form of hemoglobin used primarily to identify the average plasma glucose concentration over prolonged periods of time. It is formed in a non-enzymatic pathway by hemoglobin's exposure to high plasma levels of glucose [9]. The measurement of glycosylated hemoglobin (GHb) is one of the well-established means of monitoring glycemic control in patients with diabetes mellitus [10]. Considering this hypothesis, in this study we examined the serum lipid profile, serum creatinine & glycosylated hemoglobin (HbA_{1c}) in type 2 diabetes Sudanese patient associated with obesity

OBJECTIVES

General Objective

- To determine and to evaluate the serum lipid profile, creatinine, HbA_{1c} in obese Sudanese patient with type 2 diabetes mellitus in comparison to healthy subjects (non- diabetic non- obese) as a control group.

Specific Objectives

- To measure the serum levels of total cholesterol, triglyceride, high density lipoprotein (HDL), and low-Density lipoprotein (LDL), serum creatinine and Glycated hemoglobin in Sudanese patient with type 2 diabetes mellitus associate with obesity.
- To assess correlation between the serum levels of total cholesterol, triglyceride, high density lipoprotein (HDL), and low-density lipoprotein (LDL), and creatinine, with both; the duration of diabetes and the glycated hemoglobin %.

Hypothesis

Obesity in addition to diabetes seems to increase the risk and prevalence of complication of diabetes.

MATERIALS AND METHODS

Study Approach and Design

- This is a quantitative analytical, cross-sectional and hospital-based study.

Study Area and Period

- The study was done in Khartoum state in different hospitals (Khartoum, Omdurman and Khartoum North hospitals) during the period from February 2011 to April 2012.

Study Population and Sample Size

The study was conducted on Sudanese patients with diabetes mellitus associated with obesity as test group (n = 200) and apparently healthy subjects (non-diabetic, non-obese) as a control group, (n = 100).

Inclusion Criteria

Test group: Sudanese patients with type 2 diabetes mellitus associated with obesity.

Control group: Apparently healthy subjects (non-diabetes, non-obese).

Exclusion Criteria

Patients with history of diabetes mellitus type1, liver disease, pancreatic disease, familial hyperlipidemia, or using drugs (B blockers, diuretics, and birth control pills) had been excluded.

Ethical Considerations

The objectivities of the study were explained to all individuals, participating in this study A written consent was obtained from each participant in this study.

Data Collection and Clinical Assessment

Interview and a Questionnaire

Interview with the subjects were done to obtain the data. A questionnaire was specifically designed to obtain information which helps in either including or excluding certain individuals in or from the study respectively.

Blood Sampling, Instruments and Reagents Used

After a written consent and use of local anti-septic for the skin (70% ethanol), a fasting sample of venous blood (3mls) was collected from each individual included in the study, from the arm directly in a centrifuge tube for serum preparation. Serum levels of total cholesterol, triglyceride, low density, high density lipoproteins and creatinine were measured by using a spectrophotometer BTS-J5 and reagents from Spin react company and by Biosystem reagent company to measure the Hemoglobin A_{1C}. The method used were selected because.

All reagents are available in Sudan, easy to perform, specific and sensitive method.

Measurement of Serum Total Cholesterol, Triglyceride

Enzymatic –spectrophotometric method [11, 12].

Measurement of Serum High Density Lipoproteins (HDL) Cholesterol

Principle

Very low density lipoproteins (VLDL) and low density lipoproteins (LDL) in the sample precipitate with phosphotungstate and magnesium ions. The supernatant contains high density lipoproteins (HDL). The HDL cholesterol is then spectrophotometrically measured by means of the coupled reactions [13].

Serum low density lipoproteins (LDL) cholesterol

Is calculated from Friede wald equation as follows.

$$\text{LDL cholesterol} = \frac{\text{total cholesterol} - \text{HDL} - \text{triglycerides}}{5} \quad [14].$$

Determination of Body Mass Index

Body mass index was calculated from the formula.

BMI = weight in kilograms / square of height in meters [15].

Measurement of Serum Creatinine

Kinetic-spectrophotometric alkaline picrate [16].

Measurement of Hemoglobin A_{1C}

Principle

After preparation of the hemolysate, where the labile fraction is eliminated, hemoglobin's were retained by a cationic exchange resin. Hemoglobin A_{1C} (Hb A_{1C}) is specifically eluted after washing away the hemoglobin A_{1a + b} fraction (Hb A_{1a + b}), and is quantified by direct photometric reading at 415 nm [17].

Quality Control

The precision and accuracy of all methods used in this study were checked each time a batch was analyzed by including commercially prepared control sera.

Statistical Analysis

The data collected in this study were analyzed using SPSS computer program. The means and the standard deviations of the serum levels of total cholesterol, triglycerides, HDL-C and LDL-C, creatinine and HbA_{1C} were calculated and the independent t test was used for comparison.

Linear regression analysis was used to assess correlations between the body mass index (BMI),

HbA_{1c}%, the duration of diabetes and the serum levels of triglycerides, total cholesterol, HDL-C, LDL-C, and creatinine.

RESULTS

This study was conducted on 200 patients with type 2 diabetes as a test group and 100 apparently healthy (non- diabetic) volunteers as a control group. Age and gender of the test group were matched with the control group.

In this study the test group was composed of 112 males (56%), and 88 females (44%), whereas the control group was composed of 59 males (59%), and 41 females (41%). 33.5% (n=67) of the diabetic patients were hypertensive, 14% (n=29) have ischemic heart disease, 14% (n=28) have renal insufficiency, all diabetic patients included in this study were described as obese according to BMI calculations.

Table-1: Baseline characteristics of the test group and the control group

Variable	Test group n=200	Control group n=100	P. value
Age (years)	60.72± 9.18 (41 -85)	59.75 ± 12.36 (40 -84)	0.489
Weight (Kg)	77.30 ± 14.85 (51 - 101)	69.89 ± 14.33 (47 - 98)	0.013
Height (Cm)	164.86 ± 13.18 (140 - 190)	162.20 ± 14.50 (137 - 185)	0.068
BMI (Kg/m ²)	32.92 ± 5.29 (30.1 – 36.4)	23.86 ± 3.91 (18.7 – 29.2)	0.005

- The table shows the mean ± Std. deviation, range in brackets and probability (P).
- t- test was used for comparison.
- P- Value ≤ 0.05 is considered significant.

Table-2: Comparison of means of serum levels of T. cholesterol, HDLc, LDLc, triglycerides and creatinine of the test group and the control group

Variable	Test group n=200	Control group n=100	P value
s.t.cholesterol(mg/dL)	190.24 ± 30.53 (150 - 260)	164.63 ± 13.37 (140 - 199)	0.000
S. HDLc(mg/dL)	40.30 ± 10.099 (27 - 65)	53.95 ± 8.170 (40 - 74)	0.021
S. LDLc(mg/dL)	122.37 ± 39.39 (70 - 180)	95.06 ± 13.14 (70 - 125)	0.013
S.Triglycerides(mg/dL)	138.68 ± 40.851 (80 - 225)	100.28 ± 24.869 (60 - 150)	0.020
S. Creatinine(mg/dL)	1.07 ± 0.29 (0.6 – 1.5)	0.77 ± 0.14 (0.5 – 1.0)	0.032

- The table shows the mean ± SD deviation and range in brackets and probability (P value)
- t-test was used for comparison
- P-value ≤ 0.05 is considered significant.

Table-3: Comparison of means of serum levels of T. cholesterol, HDLc, LDLc, triglycerides and creatinine of the diabetic patients with ischemic heart disease and those without ischemic heart disease.

Variable	Patients with ischemic heart disease n=29	Patients without ischemic heart disease n=171	P value
S.total cholesterol (mg/dL)	231.07 ± 13.72	183.31 ± 38.68	0.000
S.HDLc (mg/dL)	29.38 ± 2.62	42.15 ± 9.72	0.000
S.LDL c (mg/dL)	160.45 ± 10.47	115.91 ± 26.53	0.007
S.Triglycerides mg/dL)	164.28 ± 16.13	130.94 ± 36.68	0.016
S.Creatinine (mg/dL)	1.42 ± 0.13	1.010 ± 0.27	0.025

- The table shows the mean ± SD deviation and probability (P value)
- t-test was used for comparison

- P-value ≤ 0.05 is considered significant.

Table-4: Comparison of means of serum levels of T. cholesterol, HDLc, LDLc, triglycerides and creatinine of the diabetic patients with hypertension with those without hypertension

Variable	Patients with hypertension n=67	Patients without hypertension n=133	P value
S.total cholesterol (mg/dL)	229.52 \pm 9.45	170.44 \pm 13.51	0.000
S.HDLc (mg/dL)	28.82 \pm 0.98	46.08 \pm 7.27	0.006
S.LDL c (mg/dL)	159.81 \pm 6.19	103.50 \pm 14.59	0.000
S.Triglycerides (mg/dL)	183.43 \pm 15.39	116.13 \pm 29.47	0.000
S.Creatinine (mg/dL)	1.42 \pm 0.08	0.89 \pm 0.19	0.000

- The table shows the mean \pm SD deviation and probability (P value)
- t-test was used for comparison
- P-value ≤ 0.05 is considered significant.

Table-5: Comparison of means of serum levels of T. cholesterol, HDLc, LDLc, triglycerides and creatinine of the diabetic patients with renal insufficiency with those without renal insufficiency

Variable	Patients with renal insufficiency n=28	Patients without renal insufficiency n=172	P value
S.total cholesterol (mg/dL)	232.89 \pm 13.72	183.29 \pm 26.62	0.011
S.HDLc (mg/dL)	29.82 \pm 5.21	42.00 \pm 9.67	0.010
S.LDL c (mg/dL)	160.36 \pm 11.79	116.18 \pm 26.61	0.015
S.Triglycerides (mg/dL)	183.29 \pm 19.92	131.41 \pm 38.74	0.006
S.Creatinine (mg/dL)	1.45 \pm 0.13	1.01 \pm 0.27	0.000

- The table shows the mean \pm SD deviation and probability (P value)
- t-test was used for comparison
- P-value ≤ 0.05 is considered significant.

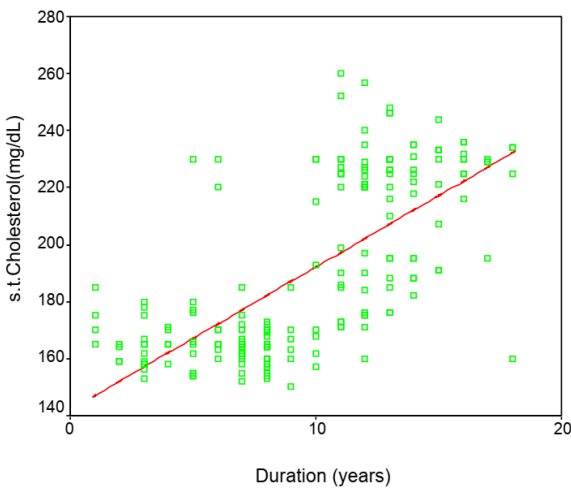


Fig-1: The relationship between the serum levels of T.cholesterol (mg/dL) and the duration of diabetes (r=0.69, P=0.029)

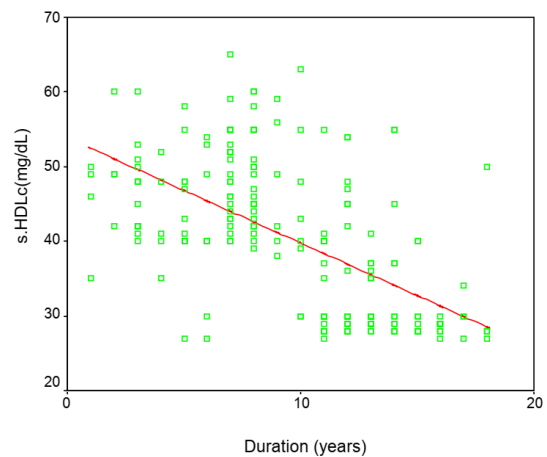


Fig-2: The relationship between the serum levels of HDLc (mg/dL) and the duration of diabetes (r=-0.59, P=0.043)

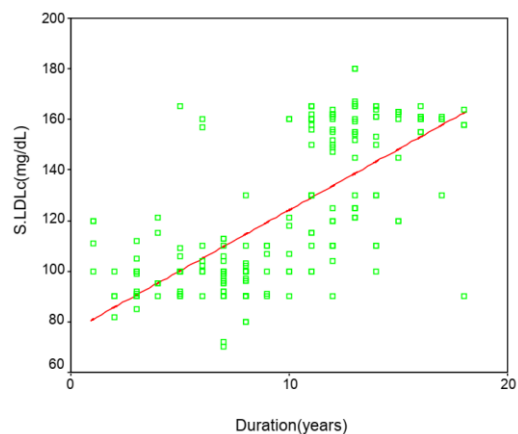


Fig-3: The relationship between the serum levels of LDLc (mg/dL) and the duration of diabetes (r=0.69, P=0.022)

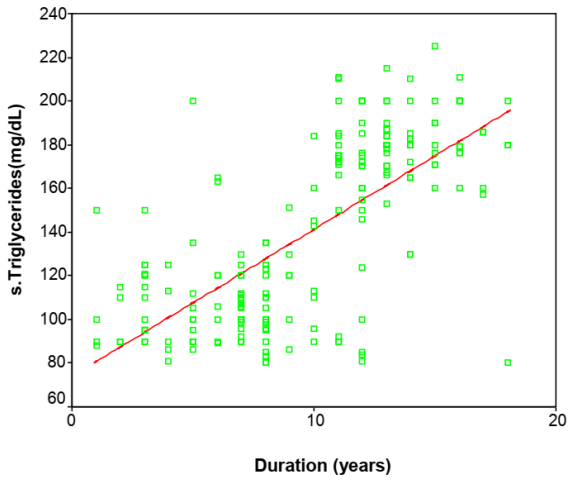


Fig-4: The relationship between the serum levels of triglycerides (mg/dL) and the duration of diabetes ($r=0.69$, $P=0.010$)

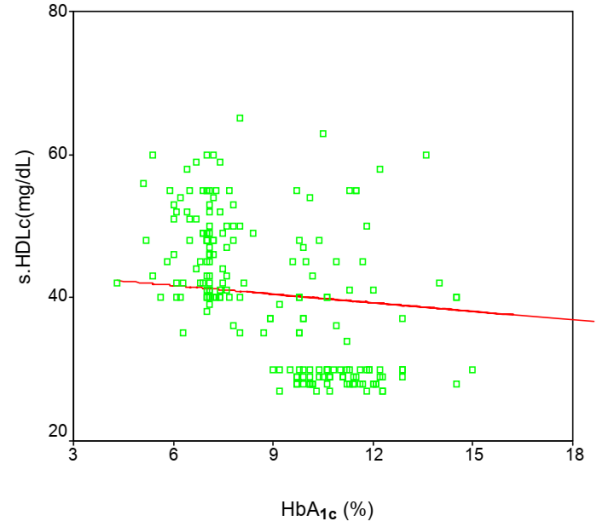


Fig-7: The relationship between the serum levels of HDLc (mg/dL) and HbA_{1c} ($r=-0.27$, $P=0.089$)

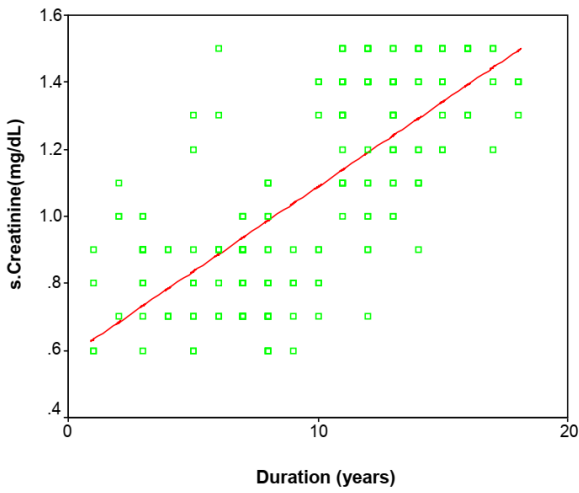


Fig-5: The relationship between the serum levels of creatinine (mg/dL) and the duration of diabetes ($r=0.72$, $P=0.000$)

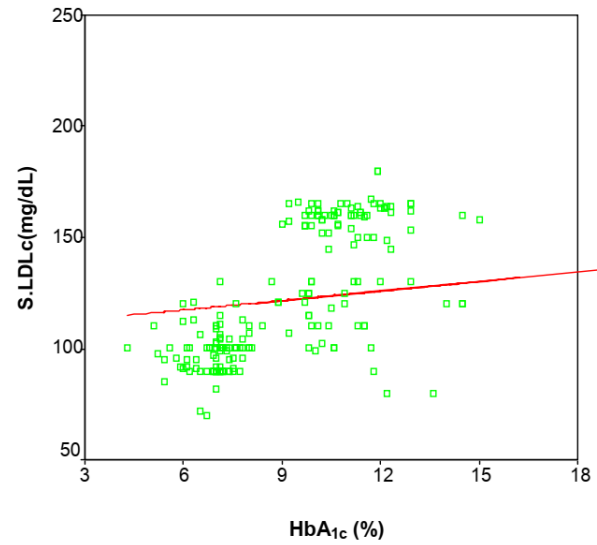


Fig-8: The relationship between the serum levels of LDLc (mg/dL) and HbA_{1c} ($r=0.32$, $P=0.117$)

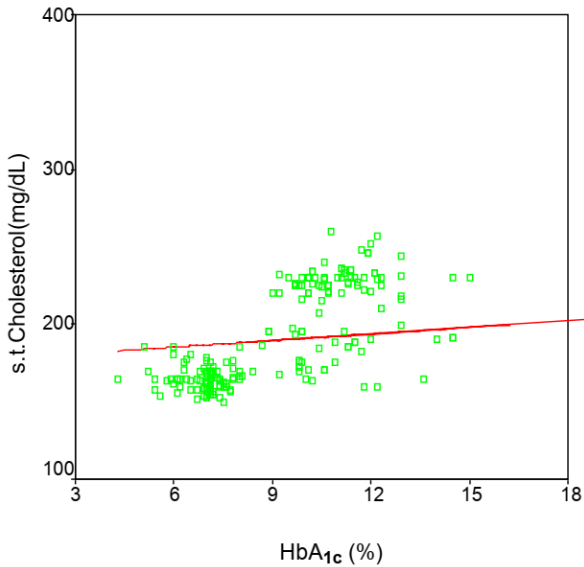


Fig-6: The relationship between the serum levels of T.Cholesterol (mg/dL) and HbA_{1c} ($r=0.32$, $P=0.083$)

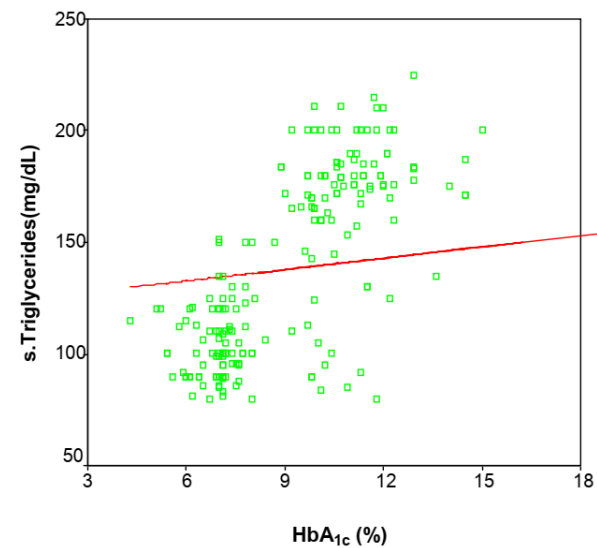


Fig-9: The relationship between the serum levels of Triglycerides (mg/dL) and HbA_{1c} ($r=0.28$, $P=0.082$)

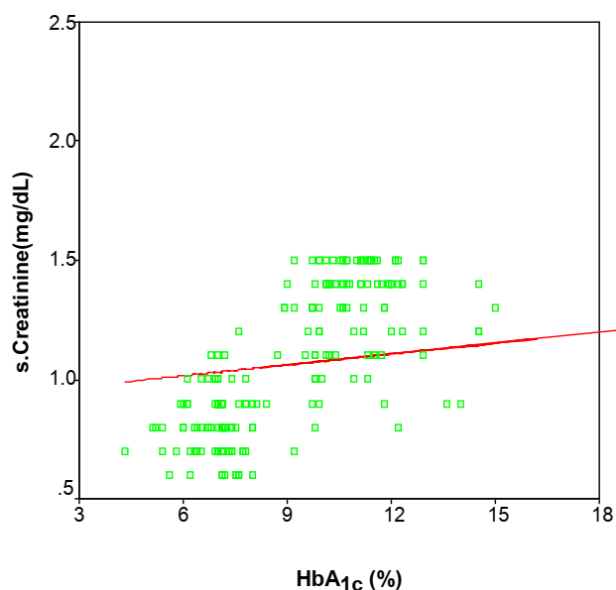


Fig-10: The relationship between the serum levels of Creatinine (mg/dL) and HbA_{1c} ($r=0.35$, $P=0.061$)

DISCUSSION

Type 2 diabetes mellitus is the most common form of diabetes. It is characterized by disorders of insulin action and insulin secretion [15], and constitutes the majority of the diabetes cases. However, these patients are at an increased risk of developing macro vascular and micro vascular complications [27]. Cardiovascular diseases (CVD) are the main cause of increased mortality in patients with diabetes, and remains the leading cause of death in patients with diabetes mellitus, accounting for 50% of all deaths [27].

Damage of endothelial wall plays the key role in the development of diabetic complications. Hyperglycemia, oxidative stress, genetic factors, disturbances of lipid metabolism, hypertension, obesity, smoking, sedentary lifestyle and various growth factors are among the major causes of chronic diabetic complications [18].

In this study a test group of 200 patients with type 2 diabetes mellitus associated with obesity (as a test group) were compared to 100 apparently healthy (non-diabetic, non-obese) volunteers, both group were matched for age and gender. Weight and body mass index were significantly raised in patients with type 2 diabetes associated with obesity compared to controls, and according to BMI calculation all of the patients were described as obese ($BMI > 30\text{kg/m}^2$).

In the present study, 33.5% of the test groups were hypertensive, 14% have ischemic heart disease, and 14% have renal insufficiency.

The current study showed a significant elevation of the means of the serum levels of total cholesterol of the test group when compared with the control group ($p=0.000$), this agrees with the result of

Idogun *et al.*, in a study done in Nigeria [19]. Dyslipidemia is a known risk factor for coronary atherosclerosis [20]. According to George *et al.*, who reported a two to three time higher risk for coronary heart disease rate in diabetic patients with lipid abnormalities [21], this agrees with a study done by Taskinem, who reported that the mean of the serum level of total cholesterol was significantly higher in diabetic patients than in healthy control subjects ($p=0.001$) [21]. The present study also shows a significant difference between the means of the serum levels of total cholesterol of the diabetic patients with ischemic heart disease when compared with those without ischemic heart disease ($p=0.000$), this is because most of Sudanese diabetic patients are badly controlled [22].

The serum levels of total cholesterol of the diabetic patients with hypertension shows a significant elevation when compared with those with normal blood pressure ($P=0.000$), this agrees with the studies done by Albrki *et al.*, [23], and Emile *et al.*, [24], who found significantly increased levels of total cholesterol among diabetics with hypertension, and disagrees with that reported by Yaron *et al.*, [25], who found no significant difference in the serum levels of total cholesterol among diabetic patients with hypertension when compared to diabetic non-hypertensive ($p=0.456$) [26].

The present study also shows a significant difference between the means of the serum levels of total cholesterol of the diabetic patients with renal insufficiency when compared with those who have normal renal functions ($P=0.011$), this is because renal insufficiency is associated with disturbance in lipid metabolism as reported by Ruderman & Haudenschild [25].

The current study shows a significant moderate positive correlation between the serum levels of total cholesterol (mg/dL) and the duration of diabetes (in year) ($r=0.69$, $P=0.029$), this agrees with that reported by Jones *et al.*, [27], who found a significant moderate positive correlation between the duration of diabetes and the serum levels of the total cholesterol ($r=0.62$), furthermore in this study there is insignificant weak positive correlation between the serum levels of total cholesterol (mg/dL) and HbA_{1c}% ($r=0.32$, $P=0.083$).

In this study the diabetic obese patients have a significant reduction in the means of the serum levels of HDL cholesterol when compared to the control group ($P=0.021$), this result agrees with that reported by Reaven [28], who found the mean of the serum levels of HDLc was significantly lower in diabetic obese patients than in the control subjects ($p=0.009$).

The current study shows a significant reduction in the serum levels of HDL among diabetic

patients with ischemic heart disease when compared with those without ischemic heart disease ($P=0.000$), this finding agrees with a study done by Garfagnini *et al.*, [29] in London, who found a significant reduction of the mean of the serum level HDLc among the diabetic patients with ischemic heart disease patients.

When compared with those without ischemic heart disease ($p=0.010$), the serum levels of HDL cholesterol of the diabetic patients with hypertension were significantly reduced when compared with those with normal blood pressure ($P=0.006$), this agrees with a study done in America by Yarone *et al.*, [25], who reported that the mean of the serum levels of HDLc was significantly reduced among diabetic patients with hypertension when compared with those with normal blood pressure ($p=0.040$).

In addition, this study also shows a significant reduction of the means of serum levels of HDL cholesterol of the diabetic patients with renal insufficiency when compared with those with normal renal functions ($P=0.010$), this finding agrees with the results of a study done by Fabian *et al.*, [30], who reported a significant reduction of the mean of serum levels of HDL cholesterol of the diabetic patients with renal insufficiency when compared with those with normal renal functions ($p=0.015$).

The present study shows a significant moderate negative correlation between the serum levels of HDL cholesterol (mg/dL) and the duration of diabetes ($r= -0.59$, $P=0.043$), Pihlajamaki *et al.*, [29] reported that hypertriglyceridemia and decreased HDL cholesterol level are recognized cardiovascular risk factors.

The Canadian Heart Association [30] reported that up to half the diabetic patients type2 have low HDL-c. Park *et al.*, [30] observed that Low HDLc is a common lipid disorder in obesity, and this agrees with that reported by Garfagnini *et al.*, [29], who found a significant moderate negative correlation between and the serum levels of HDL cholesterol (mg/dL) and the duration of type 2 diabetes (year) ($r=0.63$).

The present study shows insignificant weak negative correlation between the serum levels of HDL cholesterol (mg/dL) and HbA1C (%) ($r= -0.27$, $P=0.089$), this indicates that association of obesity and diabetes are major risk factors associated with atherosclerosis.

The present study shows a significant elevation of the mean of the serum levels of LDL cholesterol of the test group when compared with the control group ($P=0.013$), this result agrees with that reported by Grundy *et al.*, [28], who showed elevated levels of LDL, low levels of high-density lipoprotein (HDL) cholesterol, and high triglyceride levels to make

up the condition known as diabetic dyslipidemia. Also the present study shows a significant elevation in serum levels of LDL cholesterol of the diabetic patients with ischemic heart disease when compared with those without ischemic heart disease ($P=0.007$), this finding agrees with that reported by Garfagnini *et al.*, [29] in London, who found a significantly raised serum levels of LDL cholesterol of the diabetic patients with ischemic heart disease when compared with those without ischemic heart disease ($p=0.030$).

The mean serum levels of LDL cholesterol of the diabetic patients with hypertension in the current study when compared with the diabetics with normal blood pressure shows a significant elevation ($P=0.000$), this agrees with that reported by Wildman *et al.*, [31], who found a significant elevation in the serum levels of LDL cholesterol of the diabetic patients with hypertension when compared with those without hypertension ($p= 0.034$), and disagrees with the results of a study done by Yaron *et al.*, [25] who reported that there was insignificant difference in the serum levels of LDL cholesterol of the diabetic patients with hypertension when compared with those without hypertension ($p=0.0426$).

In the present study there is significantly raised mean of the serum levels of LDL cholesterol of the diabetic patients with renal insufficiency when compared with those without renal insufficiency ($P=0.015$), this finding agrees with the results of a study done by Tomlenson *et al.*, [33], who found a significantly raised serum levels of LDL cholesterol of the diabetic patients with renal insufficiency when compared with those without renal insufficiency ($p=0.041$).

The current study shows a significant moderate positive correlation between the serum levels of LDL cholesterol (mg/dL) and the duration of type 2 diabetes ($r= 0.69$, $P=0.022$), this agrees with that reported by Garfagnini *et al.*, [29], who found a significant moderate positive correlation between the duration of diabetes and the serum level of LDLc ($p=0.63$). The present study also shows insignificant weak positive correlation between the serum levels of LDLc cholesterol (mg/dL) and HbA1C (%) ($r= 0.32$, $P=0.117$), this indicates that the association of obesity and diabetic are main factors for increasing the serum levels of LDLc.

The current study shows a significant elevation of the mean of the serum levels of triglycerides among the diabetic obese patients when compared to the control group ($P=0.020$), this agrees with a study done by Taskinem, who found the mean of the serum levels of triglycerides of the test group was significantly raised when compared with the control group ($p=0.011$) [32].

The mean of the serum levels triglycerides of the diabetic group with ischemic heart disease is significantly raised when compared with those without ischemic heart disease ($P=0.016$), this agrees with the results of a study done by Laakso *et al.*, [33] in America, who found a significantly raised serum levels of triglycerides of diabetic patients with ischemic heart disease when compared with those without ischemic heart disease ($p=0.045$), this indicates that hypertriglycerideima may be a risk factor for atherosclerosis.

The mean of the serum levels of triglycerides of the diabetic group with hypertension is significantly raised when compared with the diabetics with normal blood pressure ($P=0.000$), this agrees with the result of a study done by Emile *et al.*, [34], who reported a significant increase in the serum levels of triglycerides of the diabetics with hypertension disease when compared with those without hypertension ($p=0.014$), and disagrees with that reported by Yaron *et al.*, [25], who reported insignificant difference between the mean of the serum levels of triglycerides of the diabetics with hypertension disease when compared with the diabetics without hypertension ($p=0.190$).

The present study shows a significantly raised mean of serum levels of triglycerides of the diabetics with renal insufficiency when compared with the diabetics with normal renal functions ($P=0.006$), this agrees with the results of a study done by Ruderman & Haudenschild [35], who found a significantly raised serum levels of triglycerides of the diabetics with renal insufficiency when compared with those without renal insufficiency ($p=0.040$). In addition, the current study shows a significant moderate positive correlation between the serum levels of triglycerides (mg/dL) and the duration of diabetes ($r= 0.69$, $P=0.010$).

The present study also shows insignificant week positive correlation between the serum levels of triglycerides and HbA1C (%) as shows in (Figure 4.13) ($r= 0.28$, $P=0.082$), this indicates that diabetes and obesity are major risk factors associated with hypertriglycerideima.

The current study also shows a significant increase in the mean of the serum levels of creatinine among the diabetic - obese patients when compared to the control group ($P=0.032$), this agrees with a study done by Wannamethee *et al.*, [36], who found that the mean of the serum levels of creatinine of the test group was significantly higher when compared with the control group ($p=0.002$).

The mean of the serum levels creatinine of the diabetic patients with ischemic heart disease is significantly raised when compared with those without ischemic heart disease ($P=0.025$), this finding is consistent with that reported by Matts *et al.*, [37], who

found a significantly raised serum levels of creatinine of the diabetics with ischemic heart disease when compared with those without ischemic heart disease ($p=0.005$).

The mean of the serum levels creatinine of the diabetic with hypertension is significantly raised when compared with those without hypertension ($P=0.000$), this agrees with the results of a study done by Shulman *et al.*, [38], who reported a significantly raised mean of the serum levels creatinine of the diabetic patients with hypertension when compared to diabetics with normal blood pressure ($P=0.007$).

The mean of the serum levels of creatinine of the diabetics with renal insufficiency in the current study is significantly raised when compared with those with normal renal functions ($P=0.000$), this finding is consistent with that reported by Matts *et al.*, [37], who found a significantly raised serum levels of creatinine of the diabetics with renal insufficiency when compared with those without renal insufficiency ($p=0.016$). In addition the preset study shows a significant moderate positive correlation between the serum levels of creatinine and the duration of type 2 diabetes ($r= 0.72$, $P=0.000$), also shows insignificant weak positive correlation between the serum levels of creatinine and HbA1C (%) ($r= 0.35$, $P=0.061$), this indicates that association of diabetes and obesity have a double role in causing renal damage with deterioration of renal function.

CONCLUSION

From this study, it is concluded that; in Sudanese patients with type 2 diabetes mellitus associated with obesity: Plasma total cholesterol, LDL, and triglycerides are significantly elevated in diabetics compared to non-diabetics. Plasma HDL is negatively correlated with body mass index in diabetic patients. 30% of diabetic patients have lipid abnormalities. Serum creatinine is elevated in patient with type 2 diabetes mellitus associated with obesity. There is positive correlation between the serum creatinine and the duration of the disease.

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