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A Study Measuring the Effect of High Serum Triglyceride and Cholesterol on Glucose Elevation in Human Serum

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Abstract

Objectives: The purpose of this study is to further confirm the results documented in previous studies and to test the hypothesis of the presence of any correlation and if found, the regression nature of such correlation between triglyceride and glucose levels in one hand and cholesterol and glucose levels in the other hand.

Methods: Samples were collected between March and August 2009 from 438 of both males and females from two patient groups; a) non-diabetic patients, b) non-insulin dependent type II diabetic patients. The patients' serum glucose; cholesterol and triglyceride were simultaneously determined. A comparison study was conducted on the effect of the elevated level of each of the parameters (Cholesterol and Triglyceride) on glucose elevation.

Results: The results showed that there was a significant difference in the number of cases with high glucose values >110 mg/dl among the three different study groups. There was a significant difference in the number of cases with glucose values >110 mg/dl between the two different study groups; 1) triglyceride <151 mg/dl and cholesterol >201 mg/dl, 2) triglyceride >151 mg/dl and cholesterol>201 mg/dl.

Conclusion: The elevation in triglyceride but not cholesterol has the same effect of both triglyceride and cholesterol elevation together on the association with increasing levels of high glucose in blood.

Keywords: Glucose; Cholesterol; Triglyceride; Association

Introduction

In previous studies measuring the effect of high serum triglyceride and cholesterol on glucose elevation in human serum, it was demonstrated that high serum triglyceride has a well-established association and impact on increasing cases of high glucose levels in blood,[1-4] while elevation in serum cholesterol alone has no real association or impact on increasing cases of high glucose levels in human blood.[3]

Most of the studies conducted on glucose have mentioned that 90-95% of the diabetic cases were type II diabetes mellitus. This adult type of diabetes affects older people who are obese or over weight, or have a family history of diabetes, and have restricted movement or limited exercise. In a primary study on 3000 human individuals who are in their preliminary stages of the diabetes symptoms, the results showed that decreasing weight between 5-7% on the study participants had preventive properties on 60% of the participants from developing real diabetes. Their weight was achieved by stopping the consumption of fats and by exercising. The studies on type II diabetes revealed that the patients have problems in lipids concentration and metabolism.[5] It was concluded that decreasing serum Lipids and triglyceride concentration will decrease blood glucose in the human body.

In a study monitoring lipid toxicity, the results revealed that hypertriglycemia is essential for lipid toxicity to develop.[6] Lipid toxicity would not occur in the absence of blood glucose elevation. The study concluded that lipids and glucose toxicity are interrelated and that the effect of glucose on lipid metabolism is essential. Therefore, lipids toxicity is to be associated as manifestation of glucose toxicity.

In another study evaluating sterol excretion and cholesterol absorption in diabetics and non-diabetics with /without hyperlipidemia, the results indicated that sterol excretion is elevated in those who are hyperlipidemic.[3] It was further elevated in patients with both diabetes and hyperlipidemia. However, there was no significant difference in absorbed cholesterol and excretory sterol between diabetic or non-diabetic patients with the same serum triglyceride concentrations.

The study also showed that the problem mostly associated with diabetes mellitus is hypertriglyceremia, which is associated with triglyceride and very low density lipoproteins (VLDL) synthesis but not decomposition. The study also indicated that there was no significant difference in synthesized and absorbed cholesterol between diabetic and non-diabetic patients involved in the study. The elevation in cholesterol syntheses in diabetics was due to the hyperlipidemia and more specifically due to hypertriglyceremia associated with triglyceride elevated in the serum. Thus, there was no direct association between cholesterol absorption, synthesis, excretion or blood glucose levels.

While a study assessing lipid and carbohydrate metabolism in type II diabetic patients revealed that a diet-rich in glucose caused prolonged elevation in serum triglyceride.[5]

Furthermore, a study conducted to determine the "relationship

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of Obesity to Serum Triglyceride, Cholesterol, and Uric Acid, and to Plasma-Glucose Levels" indicated that blood hypercholesterolemia was associated with blood hypertriglyceremia, meaning that both cholesterol and triglyceride elevation are not independent of each other.[7]

Moreover, a preliminary observation conducted to assess the Genetic Association Between Insulin Resistance And Total Cholesterol In Type II Diabetes Mellitus in Sri Lanka, showed that 69% of type II diabetics had a significant elevation in cholesterol.[8] While another in Nigeria based on exercise performance in relation to glucose drink and their effect on some biochemical parameters, the study highlighted significant elevations in blood glucose and serum triglyceride after 30-60-150 minutes of glucose rich drink consumption and jogging.[9]

This study was conducted to further confirm the results documented in previous studies and to test the hypothesis of the presence of any correlation and if found, the regression nature of such correlation between triglyceride and glucose levels in one hand and cholesterol and glucose levels in the other hand.

Methods

Samples were collected from patients who came to the Daboul Medical laboratory, Damascus city, Syria, between March and August 2009. The samples were gathered from two patient types; a) non-diabetic patients who came for general laboratory check-up, and b) non-insulin dependent type II diabetic patients.

The study group consisted of 438 patients of both males and females aged between 38-86 years who had their blood drawn and fasting serum glucose, cholesterol and triglyceride were simultaneously determined. The patients were divided according to their cholesterol and triglyceride levels. In the study, cholesterol levels up to 200 mg/dl and triglyceride levels up to 150 mg/dl were considered as normal, and cholesterol levels of 201-239 mg/dl and of triglyceride levels of 151-200 mg/dl were considered to be moderately high. While, cholesterol levels of >239 mg/dl and triglyceride levels of >200 mg/dl were considered to be very high levels.

A comparison study was conducted on the effect of the elevated level of each of the parameters (cholesterol and triglyceride) on glucose elevation as follows:

- Study 1- measured the number of cases of high serum glucose >110 mg/dl between the three different serum cholesterol and triglyceride groups; 1) triglyceride <151 mg/dl, cholesterol <201 mg/dl, 2) triglyceride 151-200 mg/dl, cholesterol 201-239 mg/dl, 3) triglyceride >200 mg/dl, cholesterol>239 mg/dl.
- Study 2- measured the number of cases of high serum glucose >110 mg/dl between the two different serum cholesterol and triglyceride groups; 1) triglyceride <151 mg/dl, cholesterol >200 mg/dl, and 2) triglyceride >150 mg/dl, cholesterol>200 mg/dl.
- Study 3- measured the number of cases of high serum glucose >110 mg/dl between the two different serum cholesterol and triglyceride groups; 1) triglyceride >150 mg/dl, cholesterol <201 mg/dl, and 2) triglyceride >150 mg/dl, cholesterol >200 mg/dl.
- Study 4- measured the number of cases of high serum glucose > 110 mg/dl between the two different serum cholesterol and triglyceride groups; 1) triglyceride <151 mg/dl, cholesterol >200 mg/dl, and 2) triglyceride >150 mg/dl, cholesterol<201 mg/dl.
- Study 5- measured the glucose mean and standard deviation in the following categories; 1) Individuals with normal triglyceride normal cholesterol, 2) High triglyceride normal cholesterol, 3) Normal triglyceride high cholesterol, and 4) High triglyceride high cholesterol.
- Study 6- measure both the correlation and the regression considering cholesterol as the independent variable and glucose as the dependant variable.
- Study 7- assessed both the correlation and the regression considering triglyceride as the independent variable and glucose as the dependant variable.

The Chi-Square test was used as a means of comparing the results according to the following null hypotheses; the total number of elevated cases of glucose values >110 mg/dl between the different study groups is ≤0.05 level of significance. Thus there is no significant difference in levels of elevated glucose level among the different study groups. (Tables 1-4)

The alternative hypotheses considered the total number of elevated cases of glucose values >110 mg/dl between the different study groups is not ≤0.05 level of significance. Thus, there is a significant difference in elevated glucose levels among the different study groups in such case.

Results

In this study, we reveal the influence of both elevated serum triglyceride and cholesterol levels on glucose levels in the blood by examining the effect of elevation in both triglyceride and cholesterol on glucose, (Table 1). The results indicate that 27/160 patients in Group 1 (patients with triglyceride<151 mg/dl and cholesterol <201 mg/dl) were hyperglycemic. While the triglyceride and cholesterol levels in Group 2 were 151-200 mg/dl and 201-239 mg/dl respectively, 12/46 patients were reportedly hyperglycemic. Also, with triglyceride and cholesterol levels >200 mg/dl and >239 mg/dl respectively in Group 3, 12/21 patients were found to be hyperglycemic, ($p\leq0.05$), thus there was a significant difference between the number of cases with high glucose values (>110 mg/dl)among the three study groups. (Table 1)

The effects of triglyceride elevations in the presence of normal cholesterol levels were compared with the effects of both high cholesterol and high triglyceride in Table 2. The results indicate that 17/77 patients in Group 1 (patients with triglyceride <151 mg/dl and cholesterol >201 mg/dl) were hyperglycemic. While in Group 2 (triglyceride >151 mg/dl and cholesterol >201 mg/dl), 51/120 patients were hyperglycemic, ($p\leq0.05$), hence there is a significant difference in the number of cases with high glucose values >110 mg/dl between the two study groups.

Table 1: Measuring the number of cases of high serum glucose > 110 mg/dl between groups: 1-(triglyceride <151 mg/dl, cholesterol >200 mg/dl), and 2- (triglyceride >150 mg/dl, cholesterol >200 mg/dl).

Cholesterol Triglyceride mg /dl	Total number of cases studied	Number of High glucose cases >110 mg/dl	Expected # of cases with Glucose >110 mg/dl	Chi-Square value
Cho<201 Tg<151	160	27	36	12.45
Cho 201-239 Tg 151-200	46	12	10	
Cho>239 Tg>200	21	12	5	

Table 2: Measuring the number of cases of high serum glucose > 110 mg/dl between groups: 1-(triglyceride <151 mg/dl, cholesterol >200 mg/dl), and 2- (triglyceride >150 mg/dl, cholesterol >200 mg/dl).

Cholesterol Triglyceride mg /dl	Total number of cases studied	Number of High glucose cases >110 mg/dl	Expected # of cases with Glucose >110 mg/dl	Chi-Square value
Cho>200 Tg<151	77	17	27	6.133
Cho>200 Tg >150	120	51	41	

Table 3: Measuring the number of cases of high serum glucose > 110 mg/dl between groups: 1-(triglyceride >150 mg/dl, cholesterol<201 mg/dl), 2- (triglyceride >150 mg/dl, cholesterol >200 mg/dl).

Cholesterol Triglyceride mg /dl	Total number of cases studied	Number of High glucose cases >110 mg/dl	Expected # of cases with Glucose >110 mg/dl	Chi-Square value
Cho<201 Tg>150	81	38	36	0.1865
Cho>200 Tg >150	120	51	53	

Table 4: Measuring the number of cases of high serum glucose > 110 mg/dl between groups: 1-(triglyceride <151 mg/dl, cholesterol>200 mg/dl), 2- (triglyceride >150 mg/dl, cholesterol <201 mg/dl).

Cholesterol Triglyceride mg /dl	Total number of cases studied	Number of High glucose cases >110 mg/dl	Expected # of cases with Glucose >110 mg/dl	Chi-Square value
Cho<201 Tg>150	81	38	28	7.27
Cho>200 Tg <151	77	17	27	

Table 3 shows the effect of cholesterol elevation on normal triglyceride and compares it with the effects of both high cholesterol and high triglyceride. In Group 1 (triglyceride >151 mg/dl and cholesterol <201 mg/dl), 38/81 participants were hyperglycemic. While in Group 2 (triglyceride >151 mg/dl and cholesterol >201 mg/dl), 51/120 patients were also in were hyperglycemic, ($p \leq 0.05$), hence there was no significant difference in the number of cases with high glucose values > 110 mg/dl between the two study groups.

This study also compares the effects of high triglyceride/ normal cholesterol levels with the effects of high cholesterol/ normal triglyceride on the levels of high glucose concentrations in the blood. The results showed that 17/77 patients in Group 1 with (triglyceride <151 mg/dl and cholesterol >201 mg/dl) were hyperglycemic. While in Group 2 (triglyceride >151 mg/dl and cholesterol <201 mg/dl), 38/81 patients in were also hyperglycemic, ($p \leq 0.05$). Hence, there was a significant difference in the number of cases with high glucose values >110 mg/dl between the two study groups. (Table 4)

Meanwhile, the mean and standard deviations were evaluated and found that in the 160 patients with normal triglyceride (<151 mg/dl) and normal cholesterol (<201 mg/d), the average glucose value was 102.89 mg/dl and the standard deviation was 40.88.

The study also revealed that in the 81 patients with high triglyceride (>151 mg/dl) and normal cholesterol (<201 mg/d), the average glucose value was 128.46 mg/dl and the standard deviation was 63.45. Moreover, in the 77 patients with normal triglyceride (< 151 mg/dl) and high cholesterol (>201 mg/d), the average glucose value was 106.0 mg/dl and the standard deviation was 37.29. Also, of the 120 patients with high triglyceride (>151 mg/dl) and high cholesterol (>201 mg/d), the average glucose value was 125.33 mg/ dl and the standard deviation was 46.77. (Table 5)

Furthermore, Table 6 shows the presence of any correlation and hence, the regression considering the cholesterol as the independent variable and the glucose as the dependant variable. The correlation coefficient value was 0.35 for all the 438 study participants. While in patients with normal cholesterol (<201 mg/dl), the correlation coefficient value was 0.4. The correlation coefficient in the group with moderately high cholesterol values (201-239 mg/dl) was also 0.4. Whereas, in the high cholesterol group (>239 mg/dl), the correlation coefficient value was 0.28. Likewise, in evaluating the presence of any correlation and hence, the regression considering the triglyceride as the independent variable and the glucose as the dependant variable, the correlation coefficient value was 0.095 for all the 438 studied patients. (Table 7)

Table 5: Measuring the glucose mean and standard deviation under the following categories: 1- Normal triglyceride normal cholesterol. 2- High triglyceride normal cholesterol. 3- Normal triglyceride high cholesterol. 4- High triglyceride high cholesterol.

Glucose	Normal triglyceride <151 mg/dl Normal cholesterol <201 mg/dl	High triglyceride >150 mg/dl normal cholesterol >200 mg/dl	Normal triglyceride high cholesterol	High triglyceride high cholesterol
# of patients	160	81	77	120
Average	102.8863	128.4568	106.0065	125.3292
STD	40.88006	63.45413	37.28786	46.77101

Table 6: Measuring both the correlation and the regression considering the cholesterol as the independent variable and the glucose as the dependant one.

	All the 438 individuals	Cholesterol is normal<201 mg/dl	Cholesterol is 201-239: mg/dl	Cholesterol is >239 mg/dl
Correlation	0.35	0.4	0.4	0.28
Regression P (slope)	0.19	0.28	0.116	0.27
S *y.x* (Standard error of estimate)	45.06	71.35	32.01	56.91
S*b* (Estimated standard error value	10.48	10.17	3.2	7.0
TR (The test ratio)	0.018	0.028	0.036	0.038

Table 7: Measuring both the correlation and the regression considering the triglyceride as the independent variable and the glucose as the dependant one.

Variables	All the 438 individuals	Triglyceride is normal<151 mg/dl	Triglyceride is 151-200 mg/dl	Triglyceride is >200 mg/dl
Correlation	0.095	0.075	0.040	0.043-
Regression P (slope)	0.12	0.089	0.045	-0.06
S *y.x* (Standard error of estimate)	47.93	39.67	41.41	44.34
S*b* (Estimated standard error value	26.34	18.37	11.17	13.5
TR (The test ratio)	0.0045	0.0050	0.0038	-0.0045

In both tables 6 and 7, the t test studied the regression slope at 5% levels of significance under the assumption that the slope of the samples according to the different categories presented above is zero. In the triglyceride case, the test ratio for the t test for the slope (TR) in all the different categories was <0.04, which is very small to reject our assumption. Thus, in all the cases, we accept our hypothesis that no true relationship exists between the elevation in serum triglyceride and the elevations in serum glucose in the same sample according to Table 7. In other words, in each and every single sample, elevation sin triglyceride does not necessarily, in the same manner, associate with the same level of glucose elevation when the test is performed on the same sample from the same patient.

Likewise, according to Table 6, no true forward or reverse relationship exists between the elevation in serum cholesterol and the elevation in serum glucose in every single sample when the test is performed on the same sample from the same patient. This means that high level of cholesterol does not have to be associated with the same high glucose levels in the same sample.

Discussion

This retrospective study aims to further identify the real effect of elevation of serum triglyceride and serum cholesterol separately or in combination, on glucose levels in the blood. The results in Table 1 reveals that the elevations in both triglyceride and cholesterol simultaneously have a strong impact and association with increasing levels of glucose in the blood and thus has a strong effect on diabetes.[10] The results in Table 2 declare that the difference is significant and hence the elevation in cholesterol alone does not have the same impact of association of both triglyceride and cholesterol elevation on increasing levels of high glucose in the blood.[3] While the results in Table 3 show no significant difference between the triglyceride elevation alone and the elevations in both triglyceride and cholesterol.

Thus we conclude that elevation in triglyceride but not cholesterol has the same effect of both triglyceride and cholesterol elevation on the association with increasing cases of high glucose in blood. That last statement is confirmed by the results in Table 4, which shows a significant difference between triglyceride elevations compared to the cholesterol elevations on the number of cases with high glucose levels in the blood. Therefore, triglyceride elevation has more impact than cholesterol on levels of blood glucose elevation.

By evaluating the average serum glucose values under the four categories; normal triglyceride/ cholesterol, normal triglyceride/ high cholesterol, high triglyceride/normal cholesterol, high triglyceride/high cholesterol, (Table 5) it is clear from the results that the average glucose value in the first and second categories did not exceed the normal glucose range, while it exceeded the normal value when serum triglyceride was elevated alone or together with cholesterol.[11]

Finally, the correlation and regression values clearly demonstrate that cholesterol is more positively correlated with glucose when compared with triglyceride, as is evident from the cholesterol correlation coefficient values, which varied between 0.28 and 0.4 among the four different study groups. The correlation coefficient values for the triglyceride with glucose only varied between -0.043 and 0.095. (Tables 6-7)

Upon testing the hypothesis on the existence of a real forward or inverse relationship between the triglyceride and glucose or between cholesterol and glucose for example, when one value of triglyceride increases or decreases, the corresponding glucose value also responds in the same direction, we found that the TR value (the test ratio for the t test for slope) for the cholesterol groups ranged between 0.018 and 0.038 and for the triglyceride groups between - 0.0045 and 0.0045. In both cases, the values are far below the boundaries of rejection, therefore, we accept our hypothesis (the value of B which is the slope of each tested sample regression line is 0) that there is no forward or inverse relationship exists between serum triglyceride and serum glucose as a value to value, in the same sample in one hand or between serum cholesterol and serum glucose as a value to value, in the same sample in the other hand.

Conclusion

Overall, there seems to be a strong relationship between both serum triglyceride and cholesterol elevation together and the increase levels of high blood glucose. An association was also observed between serum triglyceride elevation and the increase in high blood glucose levels. However, there was no association between serum cholesterol elevation and increases in high blood glucose. A slight correlation exists between serum cholesterol elevation and glucose elevation that are determined from the same sample. While no correlation exists between the elevation of serum triglyceride value and serum glucose value, which are determined from the same sample. Finally, no forward or inverse relationship exists between serum triglyceride and serum glucose which are determined from the same sample. The same applies for the cholesterol, as no forward or inverse relationship exists between serum cholesterol and serum glucose, which are determined from the same sample.

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