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An accurate analysis of the correlation between cholesterol and triglycerides in a few Zintan city diabetic patients

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Abstract

This study examines the relationship between triglycerides and cholesterol in diabetic patients attending medical laboratories in Zintan, and evaluates how this relationship varies according to blood sugar levels, gender, and age. Among the 912 patients analyzed, 28.9% showed low blood sugar, 33.3% normal levels, and 37.8% high levels, with significant differences between males and females according to the t-test. Age-group analysis indicated that the highest prevalence of low blood sugar occurred in the 4–20 age group, while high rates were most common in the 49–63 group, confirmed by ANOVA results. The comparison of monthly readings from January to October 2024 showed consistent averages. Overall, the findings demonstrate a statistically significant association between triglycerides, cholesterol, and glycaemic status across genders and age groups.

Keywords: Triglycerides, Cholesterol, Diabetes Mellitus, Blood Sugar, Glycaemic Status. Zintan city.

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تحليل دقيق للعلاقة بين الكوليسترول والدهون الثلاثية لدى بعض مرضى السكري في مدينة الزنتان

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الملخص

تدرس هذه الدراسة العلاقة بين الدهون الثلاثية والكوليسترول لدى مرضى السكري الذين يراجعون المختبرات الطبية في مدينة الزنتان، وتقيّم كيفية اختلاف هذه العلاقة باختلاف مستويات السكر في الدم والجنس والعمر. من بين 912 مريضًا خضعوا للتحليل، أظهر 9.28% منهم انخفاضًا في مستوى السكر في الدم، و3.33% منهم مستويات طبيعية، و8.37% منهم مستويات مرتفعة، مع وجود فروق ذات دلالة إحصائية بين الذكور والإناث وفقًا لاختبار .t أشار تحليل الفئات العمرية إلى أن أعلى معدل انتشار لانخفاض سكر الدم كان في الفئة العمرية 4–20 عامًا، بينما كانت المعدلات المرتفعة أكثر شيوعًا في الفئة العمرية 49–63 عامًا، وهو ما أكدته نتائج تحليل التباين .(ANOVA) أظهرت مقارنة القراءات الشهرية من يناير إلى أكتوبر 2024 متوسطات ثابتة. بشكل عام، تظهر النتائج وجود ارتباط ذي دلالة إحصائية بين الدهون الثلاثية والكوليسترول ومستوى سكر الدم لدى الجنسين والفئات العمرية.

الكلمات المفتاحية: الدهون الثلاثية، الكوليسترول، داء السكري، سكر الدم، مستوى سكر الدم، مدينة الزنتان.

I. Introduction

Diabetes is a metabolic disorder characterized by chronic hyperglycaemia due to insulin deficiency or resistance, leading to serious complications if untreated [1,2]. Type 1 diabetes arises from beta-cell destruction, whereas type 2 diabetes results from insulin

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resistance. Diabetes increases the risk of cardiovascular disease through impaired lipid metabolism, typically presenting with elevated LDL (bad) cholesterol and reduced HDL (good) cholesterol, contributing to atherosclerosis and heart attacks [3,4]. Unhealthy lifestyles are the predominant contributor towards cholesterol levels and can be managed via diet, exercise and medication.

Elevated HbA1c is associated with higher cardiovascular risk, whereas HDL-C provides a protective effect, although its optimal level for diabetic patients is not fully established. A 2017 study in Sabha, Libya, evaluated biochemical and lipid profiles in 120 diabetic patients compared to non-diabetic individuals. Results showed significantly higher glucose levels in diabetics, with elevated cholesterol and triglycerides (P=0.02 and P=0.0001, respectively), while LDL and HDL differences were not significant. Triglycerides, the most abundant body fat, serve as energy storage and are transported in blood via lipoproteins. They are classified as saturated (without double bonds) or unsaturated (with double bonds) [5,6].

Triglycerides and cholesterol are biomarkers associated with diabetes. Insulin resistance leads to elevated blood sugar and lipid levels, with high LDL and low HDL cholesterol being common in diabetic patients, increasing the risk of atherosclerosis and heart disease [7,8]. Diabetes is defined as a chronic disease resulting from insulin deficiency or impaired insulin function. Globally, 285 million people were living with diabetes in 2010, with projections indicating a rise to 438 million by 2030. The World Health Organization reports that 80% of diabetes-related deaths occur in low-income countries. The main types include type 1 diabetes, resulting from the destruction of beta cells; type 2 diabetes, associated with obesity and insulin resistance; gestational diabetes; and secondary diabetes, resulting from other diseases or medications [9,10]. Causes of diabetes include genetic factors, obesity, lipid disorders, stress, certain medications, and viral or bacterial infections. Diagnosis and prevention require lifestyle management, regular laboratory tests, and insulin or oral medications, depending on the type.

Genetic Influence on Lipid Metabolism: APOE Gene. While metabolic factors and lifestyle choices remain the predominant

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contributor to cholesterol levels, genetic predisposition play a significant role in lipid metabolism along with its effect among diabetes patients, with key genes associated with increased and decreased LDL and HDL cholesterol levels as well as possible effects in modified lipid profiles and cholesterol-triglyceride correlations due to various genetic variations among patients.

The APOE gene provides the instructions to making the Apolipoprotein E, associated with combining lipids in the body to form lipoprotein molecules. It consists of 3 allelic variants e2, e3, and e4, with e3 being associated with standard and neutral cholesterol levels, e2 being associated with lower LDL cholesterol but elevated triglycerides and e4 with higher total LDL cholesterol. This study aims to investigate the relationship between diabetes and elevated cholesterol and triglycerides, assess their impact on diabetic complications, and identify factors influencing lipid levels in diabetic patients. Findings are expected to inform strategies combining lifestyle modifications and medication to optimize blood sugar and lipid management, ultimately reducing cardiovascular risk.

II. Study system discretion.

Data and statistics were collected from the archives and systems of medical laboratories for individuals attending these laboratories. The cases were subsequently classified according to age, gender, year, and normal reference ranges for each test. The study included samples obtained from several medical laboratories in the city of Zintan between January and October 2024. After organizing the data, it was submitted to a statistics specialist for detailed analysis. The analysis involved measuring blood glucose, cholesterol, and triglyceride levels, with comparisons conducted according to gender, age, year, and normal reference ranges. Statistical analysis was performed using SPSS version 25, a widely recognized software in scientific research and statistical analysis.

III. Materials and Methods

This section of the research deals with the laboratory analysis of blood glucose, cholesterol, and triglyceride samples, organized into the following points:

1. Fasting Blood Glucose Analysis:

Fasting blood glucose tests are used to measure the level of glucose in the blood, typically after fasting for 8 to 12 hours. Samples are

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sent to blood glucose analysers or automatic glucose measurement devices, where glucose levels are measured and displayed within a few minutes. The normal fasting blood glucose range is defined as 70–100 mg/dL.

2. Cholesterol Analysis:

Cholesterol analysis is used to measure blood lipid levels, including total cholesterol, LDL (low-density lipoprotein, "bad" cholesterol), and HDL (high-density lipoprotein, "good" cholesterol). Samples are collected in red test tubes containing anticoagulant, then sent to cholesterol analyzers such as COBAS or ADVIA to measure total cholesterol, LDL, HDL, and triglycerides.

This process typically takes 10 to 15 minutes to obtain results. The normal range for total cholesterol is less than 200 mg/dL, for LDL less than 100 mg/dL, and for HDL 60 mg/dL or higher.

3. Triglycerides Analysis:

Samples for triglyceride analysis are placed in red or blue test tubes specifically designated for this purpose and then analyzed using devices such as COBAS. Triglyceride levels are measured using chemical or enzymatic methods, and the results are displayed on the device screen. The normal triglyceride range is less than 150 mg/dL.

The experiments were conducted on individuals visiting medical laboratories in Zintan city during the period from January 2024 to October 2024. The study involved the collection of 912 samples of triglycerides, cholesterol, and glucose, targeting all age groups of both genders. Data were collected from six different laboratories using archival records and the available laboratory systems, as follows:

1. **Zintan General Hospital:** 50 cases were collected from the archives during the period from 15 August to 29 September 2024, including 35 females and 15 males.
2. **Al-Burhan Medical Analysis Laboratory:** 109 cases were collected from the archives during the period from 1 January to 6 October 2024, including 55 females and 54 males.
3. **Al-Taqwa Zintan Clinic:** 109 cases were collected from the archives during the period from 21 April to 15 October 2024, including 63 females and 46 males.
4. **Al-Jorwah Specialized Clinic:** 251 cases were collected from the laboratory's electronic system during the period from 1 January to 30 September 2024, including 127 females and 124 males.

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5. **Al-Taqwa Residential Clinic:** 240 cases were collected from the electronic system during the period from 10 January to 30 September 2024, including 140 females and 100 males.
6. **Centre for Women's and Obstetrics Diseases:** 153 cases were collected from the archives during the period from 15 March to 30 August 2024, including 77 females and 76 males.

The data were categorized and analyzed by gender, as shown in Table 1, to ensure balanced representation, thus enhancing the statistical accuracy of the study results.

Table 1. Number of Cases for Some Medical Laboratories Within the City of Zintan (2024)

Laboratory	Al-Taqwa Clinic Laboratory	Al-Taqwa Residential Clinic Laboratory	Al-Burhan Medical Laboratory	Laboratory of Obstetrics and Gynecology Treatment	Al-Jarwa Specialized Clinic Laboratory	Zintan General Hospital Laboratory
Males	46	100	54	76	124	15
Females	63	140	55	77	127	35
Total	109	240	109	153	251	50

IV. Results and Descriptive Data Analysis:

a. Distribution of Sample Members by Blood Sugar Levels and Sex.

Table 2 and Figure 1shows the distribution of the sample members according to blood sugar levels and sex. It reveals that the majority of the sample, both males and females, had high blood sugar levels, totalling 37.8% (344 cases). Of these, 196 females (21.5%) had high levels, compared to 148 males (16.3%). Meanwhile, 33.3% had normal blood sugar levels, totalling 304 cases (176 females, 19.3%) and 128 males (14%). Finally, 264 males (148 females, 16.2%) had low blood sugar levels, as illustrated in the table and graph below.

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TABLE 2. The sugar Level, Percentage, and Number of Males and Females

			Sex		Total
			Male	Female	
Sugar	Low	Number	116	148	264
		Percentage %	12.7%	16.2%	28.9%
	Normal	Number	128	176	304
		Percentage %	14%	19.3%	33.3%
	High	Number	148	196	344
		Percentage %	16.3%	21.5%	37.8%
Total		Number	392	520	912
		Percentage %	43%	57%	100%

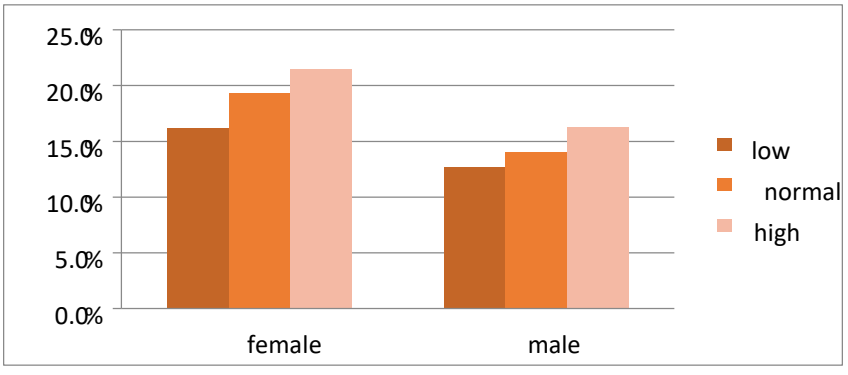

Fig.1. Distribution of the sample according to sugar level and gender.

The Table 3 and Figure 2 shows the distribution of the sample according to blood sugar levels and age. It was found that the majority of age groups had high blood sugar levels. Analysis of the statistics revealed that the age group with the highest high blood sugar was 49-63 years old, with 104 cases (11.4%). The age group with no high blood sugar was 4-18 years old (0%). The 19-33 age group had 60 cases (6.6%), while the 34-48 age group had 80 cases (8.8%), and the 64-78 age group also had 80 cases (8.8%). The 79-92 age group had 20 cases (2.2%). The age group with the highest normal blood sugar levels was 49-63 years old, with 88 cases (9.6%), followed by the 64-78 age group with 20 cases (8.8%). The 19-33 age group had 60 cases, representing 6.6% of the total. This

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was followed by the 34-48 age group with 56 cases (6.1%), and then the 79-92 age group with 12 cases (1.3%). The age group with the lowest normal rate was 4-18 years old, with 8 cases (0.9%). The 3448-age group had the lowest rate, with 96 cases (10.5%), followed by the 49-63 age group with 72 cases (7.9%), then the 64-78 age group with 52 cases (5.7%), followed by the 19-33 age group with 40 cases (4.4%), and then the 79-92 age group with 4 cases (0.4%). The age group with the lowest rate was [missing information]. For the 4-18 category, there are 0 cases and a percentage of 0%. This is evident from the table and graph below.

TABLE 3. The Sugar Level and Percentage among the Age Groups

			Age						Total
			4-18	19-33	34-48	49-63	64-78	79-93	
sugar	Low	Number	0	40	96	72	52	4	264
		Percentage %	%0	%4.4	%10.5	%7.9	%5.7	%0.4	%28.9
	Normal	Number	8	60	56	88	80	12	304
		Percentage %	%0.9	%6.6	%6.1	%9.6	%8.8	%1.3	%33.3
	High	Number	0	60	80	104	80	20	344
		Percentage %	%0	%6.6	%8.8	%11.4	%8.8	%2.2	%37.7
Total		Number	-	160	232	264	212	36	912
		Percentage %	-	%17.6	%25.4	%28.9	%23.2	%3.9	%100

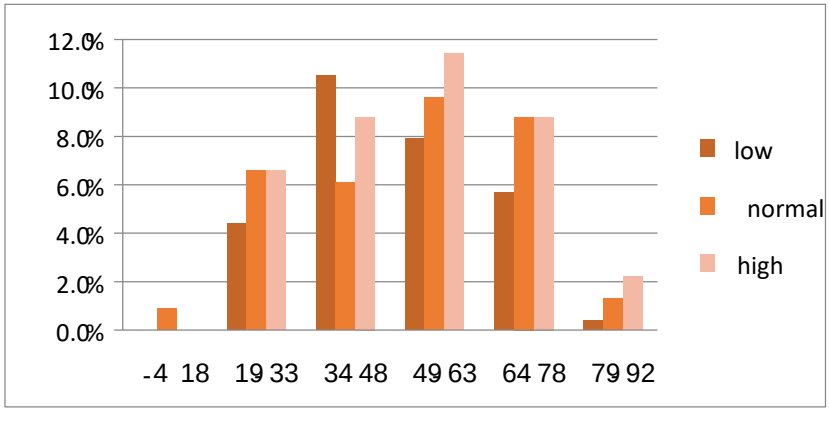

Fig.2. The Distribution of the Sample Members According to Sugar Level and Age

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The Table 4 and Figure 3 shows the distribution of the sample members according to cholesterol levels and gender. It shows that the majority of the sample members, both males and females, had a normal level, at a rate of 65.8%, totalling 600 cases of males and females. The number of females, 360 cases, had high levels, at a rate of 39.5%, more than the number of males, which was 240 cases, at a rate of 26.3%. Meanwhile, 15.8% had a high level, totalling 144 cases of males and females, with the number of females being 72 cases, at a rate of 7.9%, and males being 72 cases, at a rate of 7.9%. Meanwhile, the number of cases with a low level was 168 cases, at a rate of 18.4%, of males and females, with the number of females being 88 cases, at a rate of 9.6%, and males being 80 cases, at a rate of 8.8%. This is evident from the table and the graph below.

TABLE 4. The Cholesterol Level, Percentage, and Number of Males and Females

			Sex		Total
			Male	Female	
Cholesterol	Low	Number	80	88	168
		Percentage %	%8.8	%9.6	%18.4
	Normal	Number	240	360	600
		Percentage %	%26.3	%39.5	%65.8
	High	Number	72	72	144
		Percentage %	%7.9	%7.9	%15.8
Total		Number	392	520	912
		Percentage %	%43	%57	%100

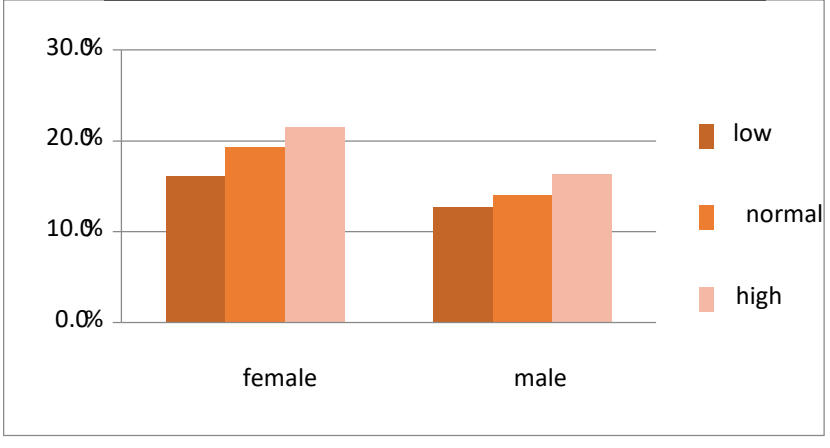

Fig.3. Distribution of the Members According to Cholesterol Levels and Gender.

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The Table 5 and Figure 4 shows the distribution of the sample according to cholesterol levels and age. It was found that the majority of age groups had normal levels. Analysis of the statistics revealed that the age group with the highest normal levels was 49-63 years, with 176 cases (19.3%). The age group with no normal levels was 79-92 years (0%). The 19-33 age group had 120 cases (13.2%), while the 34-48 age group had 132 cases (14.5%), and the 64-78 age group had 136 cases (14.9%). The 4-18 age group had 4 cases (0.4%). The lowest cholesterol levels were found in the 34-48 age group (56 cases, 6.1%), followed by the 49-63 and 64-78 age groups, each with 44 cases. The number of cases was 4.8%, followed by the 79-92 age group with 32 cases (3.5%), followed by the 19-33 age group with 24 cases (2.6%). The two age groups with the highest rates were 3448 and 49-63, with 44 cases (4.8%), followed by the 64-78 age group with 32 cases (3.5%), followed by the 19-33 age group with 16 cases (1.8%), followed by the 4-18 and 79-92 age groups with 4 cases (0.4%). This is evident from the table and graph below.

Table 5. Cholesterol Level and Percentage in the Age Groups

			Age						Total
			4-18	19-33	34-48	49-63	64-78	79-93	
Cholesterol	Low	Number	0	24	56	44	44	32	200
		Percentage %	%0	%2.6	%6.1	%4.8	%4.8	%3.5	%21.9
	Normal	Number	4	120	132	176	136	0	568
		Percentage %	%0.4	%13.2	%14.5	%19.3	%14.9	%0	%62.3
	High	Number	4	16	44	44	32	4	144
		Percentage %	%0.4	%1.8	%4.8	%4.8	%3.5	%0.4	%15.8
Total		Number	8	160	232	264	212	36	912
		Percentage %	%0.9	%17.5	%25.4	%28.9	%23.2	%3.9	%100

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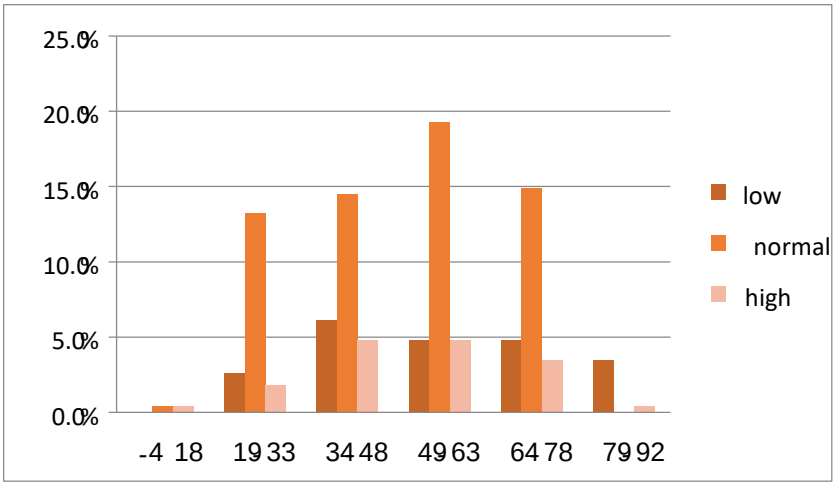

Fig.4. Distribution of the Sample Members According to Cholesterol Levels and Age.

The Table 6 and Figure 5 shows the distribution of the sample according to triglyceride levels and gender. It shows that the majority of the sample, both males and females, have a normal level, at a rate of 64.9%, with a total of 592 cases of males and females. The number of females was 328 cases, with 36% having normal levels, more than the number of males, which was 264 cases, with 28.9%. Meanwhile, 35% have a high level, with a total of 320 cases of males and females, with the number of females being 192 cases, with 21%, and males being 128 cases, with 14%. This is evident from the table and the graph below.

Table 6. Triglyceride Level, Percentage, and Number of Males and Females

			Sex		Total
			Male	Female	
Triglycerides	Normal	Number	264	328	592
		Percentage %	%28.9	%36	%64.9
	High	Number	128	192	320
		Percentage %	%14	%21	%35
Total		Number	392	520	912
		Percentage %	%43	%57	%100

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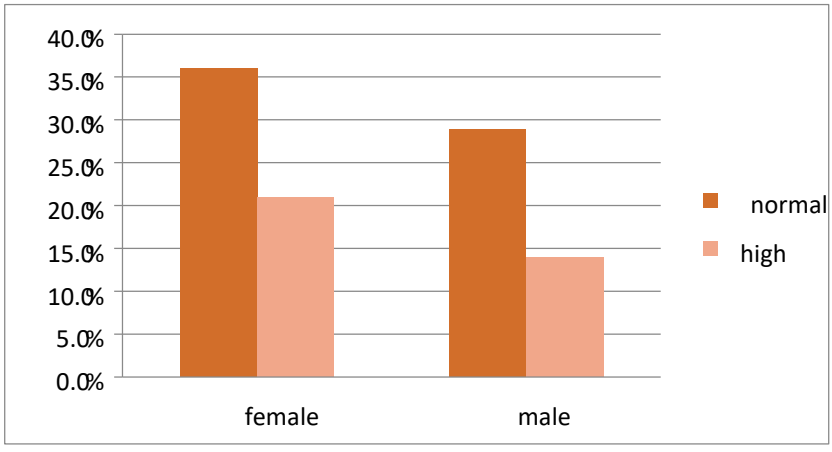

Figure .5. Distribution of the Sample Members According to Triglyceride Levels and Gender.

However, table 7 and figure 6 show the distribution of the sample members according to triglyceride levels and age. It was found that the majority of age groups had normal levels across different age groups. Through statistical analysis, it was found that the age group with the highest normal level was 49-63 years, with 168 cases, representing 18%. The age group with the lowest normal level was 4-18 years, representing 0.4%. The age group of 19-33 years had 100 cases, representing 11%. The age group of 34-48 years had 152 cases, representing 16.7%. The age group of 64-78 years had 140 cases, representing 15.4%. The age group of 79-92 years had 28 cases, representing 3.1%. As for the group with the highest high level, it was 49-63 years, with 96 cases, representing 10.5%, followed by the group of 34-48 years, with 80 cases, representing 8.8%. This was followed by the 19-33 age group, with 72 cases and a rate of 7.9%, followed by the 19-33 age group with 60 cases and a rate of 6.6%, followed by the 79-92 age group with 8 cases and a rate of 0.9%, and the lowest age group with a normal rate was the 418-age group with 4 cases and a rate of 0.4%, as shown in the table and graph below.

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Table 7. Triglyceride Levels and Percentages in Different Age Groups.

			Age						Total
			4-18	19-33	34-48	49-63	64-78	79-93	
Triglycerides	Normal	Number	4	100	152	168	140	28	592
		Percentage %	%0.4	%11	%16.7	%18.4	%15.4	%3.1	64.9 %
	High	Number	4	60	80	96	72	8	320
		Percentage %	%0.4	%6.6	%8.8	%10.5	%7.9	%0.9	35.1 %
Total		Number	8	160	232	264	212	36	912
		Percentage %	%0.9	%17.5	%25.4	%28.9	%23.2	%3.9	%100

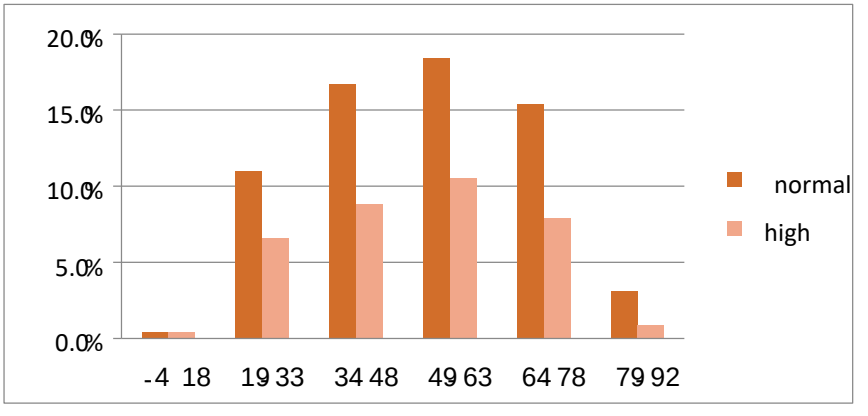

Figure.6.: Distribution of the Sample Members According to Triglyceride Levels and Age.

b. Relationship between Blood Sugar Levels and Gender

As for Table 8 and Figure 7, they illustrate the distribution of the sample members according to triglyceride levels and age shows the distribution of the sample according to blood sugar levels and gender. The results indicate that the average blood sugar level in females is significantly lower than in males, with an average of 101.5 mg/dL for females and 185.0 mg/dL for males. The distribution of females is characterized by its close proximity to the mean values (standard deviation: 31.3), while the distribution of males shows considerable variation with high extreme values

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(standard deviation: 119.0). The statistical results indicate clear differences between the sexes in blood sugar levels**.**

❖ **Statistical test used: Scientific samples t-test.**

- Null hypothesis (H0): There is no statistically significant difference in blood sugar levels between the sexes.
- Alternative hypothesis (H1): There is a statistically significant difference in blood sugar levels between the sexes.

Table 8. Relationship between Blood Sugar Levels and Gender

Sex	number (n)	average (mean)	standard deviation (std)	Level of significance (Sig.)
Female	520	101.5	31.3	< 0.001
Male	392	185.0	119.0	

Based on the t-test result and the significance level ($p < 0.001$), we reject the null hypothesis (H0) and accept the alternative hypothesis (H1), indicating that there is a statistically significant difference in sugar levels between males and females.

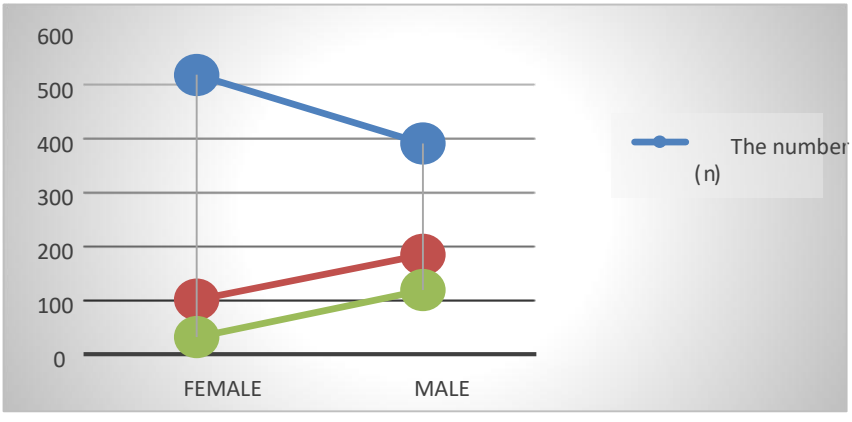

Figure. 7.: Shows the distribution of the sample according to blood sugar levels and gender.

c. Studying the relationship between blood sugar levels and age groups:

Finally, table 9 shows the distribution of the sample according to blood sugar levels and age groups.

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The results indicate that the 21-40 age group has the highest mean blood sugar level (220.0), reflecting the presence of cases with high extreme values.
The 41-60 and 61-80 age groups show more stable levels. Statistical test used: One-way ANOVA.

•Null hypothesis (H0): There is no statistically significant relationship between blood sugar levels and age groups.
•Alternative hypothesis (H1): There is a statistically significant relationship between blood sugar levels and age groups.

Table 9. Relationship between Blood Sugar Levels and Age.

age group	The number (n)	Average (mean)	Standard deviation (std)	Minimum (min)	Highest (max)	Significance level (Sig.)
0-20	50	80.0	10.0	70.0	90.0	< 0.001
21-40	150	220.0	183.8	90.0	350.0	
41-60	300	106.0	39.3	71.0	160.0	
61-80	200	107.5	17.7	95.0	120.0	
81-100	212	135.0	77.8	80.0	190.0	

Based on the result of the ANOVA test and the significance level ($p < 0.001$), we reject the null hypothesis (H0) and accept the alternative hypothesis (H1), which indicates that there is a statistically significant relationship between sugar levels and age groups as shown in Figure 8.

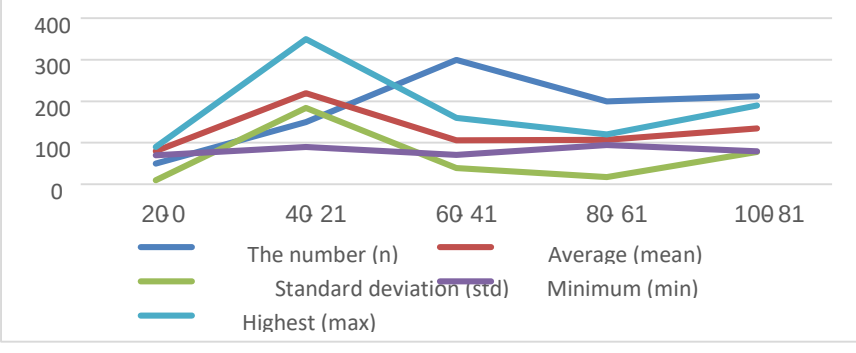

Figure. 8. Distribution of the Sample Members According to Blood Sugar Levels and Age Groups.

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Genetic data was not directly assessed in the study leading to a difference in APOE genotypes among patients, partially explaining variability observed in Cholesterol-Triglyceride correlation.

IV. Conclusion

This study of 912 cases from Zintan demonstrates clear associations between blood glucose levels and both cholesterol and triglycerides across gender and age groups. Glucose analysis showed that 28.9% of participants had low levels, 33.3% were normal, and 37.8% were elevated, with a significant gender difference confirmed by t-test and consistent with findings from Zliten. Age-based results indicated the highest low-glucose rate (5.48%) in the 4–20 years group, while elevated glucose peaked in the 49–63 years group; ANOVA further showed significant age effects, with the highest elevation (23.24%) in individuals aged 81–100 years. Cholesterol findings revealed 18.4% with decreased levels (9.6% females, 8.8% males), 65% within normal limits, and 15.8% with elevated levels. The greatest increase (4.8%) occurred in the 34–63 years group, while the largest decrease (6.1%) was in the 34–48 years group. A significant gender association was also identified, with females showing higher rates across most age groups. For triglycerides, 64.9% of participants had normal levels, 35% showed elevated levels, and no decreases were detected; the highest elevation (10.5%) occurred in the 49–63 years group. Significant correlations were found between cholesterol and triglycerides among diabetic patients, and between cholesterol, HDL, and LDL, consistent with previous studies linking diabetes to lipid abnormalities. Overall, these results highlight that lipid metabolism disturbances—particularly in cholesterol and triglycerides—are strongly associated with variations in blood glucose levels, emphasizing the need for integrated monitoring and management of glucose and lipid profiles to reduce metabolic risks in diabetic and at-risk populations.

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