RESEARCH ARTICLE

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Biomarker-Based Insights into the Impact of Type 2 Diabetes on Cardiovascular Health

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Abstract

This study explores the intricate relationship between type 2 diabetes mellitus (T2DM) and cardiovascular health, with a particular focus on the role of key biomarkers involved in atherosclerosis progression. Using a retrospective observational study design, the trajectories of oxidized LDL levels were analyzed across distinct cohorts, including individuals with myocardial infarction (MI) with and without diabetes, as well as a non-diabetic control group. The aim was to elucidate the impact of diabetes-associated pathophysiological mechanisms on the progression of hypercholesterolemia. Correlation analyses revealed significant associations between T2DM status and several cardiovascular biomarkers, including Troponin, fasting blood sugar (FBS), triglycerides, cholesterol, HDL, and VLDL. Elevated oxidized LDL levels were observed in T2DM patients, particularly in those with MI, indicating a strong predisposition to cardiovascular complications. A significant difference in the mean oxidized LDL levels was identified across all groups ($p < 0.001$), highlighting its potential role as a critical biomarker in assessing cardiovascular risk in T2DM patients. These findings underscore the importance of monitoring oxidized LDL and other cardiovascular biomarkers in T2DM patients to better understand the mechanisms underlying cardiovascular disease progression and to develop targeted therapeutic strategies for this high-risk population.

Keywords: Heart Health, Type 2 Diabetes, Biomarker Analysis

Introduction

The progression of atherosclerosis is influenced by many different variables such as artery inflammation and fat buildup. The atherosclerosis is more likely to be accelerated with patients suffering from diabetes, this will arsis the risk of having strokes, and heart failure [1]. A complicated combination of variables and factors are major causes of vascular disease such as oxidative damage and metabolic abnormalities [2]. The most crucial component of factors and variables that have been identified to contribute to atherosclerosis in diabetics is oxidized low-density lipoprotein (LDL)[3].

The development of atherosclerosis is affected due to the Oxidized low-density lipoprotein, which stimulates the reactions of inflammation in blood vessels which results in the development of plaque. These plaques affect how blood flows leading to many diseases such as heart attacks or strokes. These plaques can obstruct blood flow, which could lead to heart attacks or strokes in those who are impacted. [4]. In addition, smooth muscle cell growth can be stimulated in blood vessel walls by the oxidized low-density lipoprotein (LDL) which will exacerbate atherosclerosis [5].

Therefore, type 2 diabetes which is characteristic of underlying metabolic abnormalities will increase the effects of oxidized low-density lipoprotein (LDL) in patients. The process of inflammation also can be speeded in the human body due to high levels of glucose which will speed up the oxidation of LDL [6]. To reduce the possibility of developing atherosclerosis oxidized low-density lipoprotein (LDL) levels need to be checked closely with patients having diabetes. These patient needs to change their lifestyle and the diet they are using, with the correct medications the amount of oxidized low-density lipoprotein (LDL) can be controlled [7, 8]. Endothelial dysfunction is caused by Oxidized LDL cholesterol this is done by lowering the availability of oxide which makes it easy for cells to migrate to the inner layer of the artery. The production of foam cells is also presented by oxidized low-density lipoprotein (LDL) gathering cholesterol by encouraging astrocytes and changing it into lipid-filled foam cells [9]. This study investigates the role of oxidized low-density

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lipoprotein and its contributions to diabetes by using different analysis techniques to gain insight of the variable and factors affecting it.

Previous Related Studies

Patients with diabetes can develop atherosclerosis more easily [10, 11]. This is due to several factors Table 1 shows the oxidized low-density lipoprotein and its role in developing atherosclerotic plaque in diabetics.

Table 1(a): Previous related studies

Method	Results	Limitations	Author(s)
Longitudinal cohort study design	The results have shown a significant difference in oxidized LDL levels in individuals with varying T2DM status., Triglyceride, Cholesterol, HDL, VLDL) were observed.	Findings may not be generalizable because of the single-center recruitment of the sample and the failure to control for any confounding variables present. However, the follow-up will allow for the evaluation of how the factors change over time.	Dienemann T et al. and Piolatto M et al. [12, 13]
Advanced statistical analysis	The results of the correlation analysis indicated that the individual's T2DM status and cardiovascular biomarkers are significantly correlated, however, when the individual experiences a myocardial infarction, there are noticeable changes in the biomarker profiles.	Given that the study is observational, it is plausible that the small sample size impairs statistical power and that the correlation shown is false.	Emdin C A et al. and Zheng B et al. [14, 15]

Table 1(b): Previous related studies

Method	Results	Limitations	Author(s)
Clinical trial	They concluded that endothelial function appeared to be improved in diabetic patients receiving LDL apheresis treatment.	Long-term results and generalizability are limited by small sample sizes and brief follow-up periods.	Gustavson K et al. [16]
Subgroup analyses based on T2DM status	Subgroup analyses are used to examine the distinct effects of T2DM status on cardiovascular biomarkers and health outcomes.	Difficulties in accounting for all pertinent variables	Austin G et al. [17]
Review article	Summarizes the numerous ways that oxidized low-density lipoprotein (LDL) causes diabetic atherosclerosis, emphasizing the necessity for more studies on preventive measures.	Few original data points to current gaps in knowledge without offering any new research.	Scioli M G et al. [18]

Table 1 shows there is a need for more comprehensive research to be conducted by examining the relationship between T2DM status and specific cardiovascular disease markers of Troponin, fasting blood sugar (F.B.S.), triglycerides and cholesterol, HDL, and VLDL.

Method

This research uses a retrospective observational study design research method to investigate the relation of clinical parameters and biomarkers, which are composed of oxidized low-density lipoprotein, in patients with T2DM and patients without T2DM. The participants who were considered in this research were adults who were confirmed and diagnosed with T2DM and subclinical atherosclerosis along with participants without T2DM. The populations in this research were adults with ages between 40-66 years with and without T2DM diagnosed. One year was also considered in the current analysis such that data at baseline would be used to assess the changes in biomarkers over time. The data that was sought to be collected was varied as learners were to provide their basic information such as age, gender, height, and weight, but there were also clinical parameters and biomarkers from these patients' medical records. These included LDL levels, Oxidized LDL levels, Troponin levels, Fasting blood sugar levels, Triglyceride levels, Total cholesterol levels, High-density lipoprotein cholesterol levels, and very low-density lipoprotein cholesterol levels. The primary focus is comparing oxidized LDL levels in people with type 2 diabetes and those without. In addition, checking any changes in other health markers and clinical pointers in each group.

The statistical analysis was performed using SPSS to determine the relationship between clinical parameters and biomarkers by using different analysis techniques to focus on how oxidized LDL

levels are different in persons with and without T2DM patient groups. The principal outcome indicator will be the variation in oxidized LDL levels between individuals with and without type 2 diabetes. To accomplish this, additional metrics such as variations in other biomarkers along with additional clinical characteristics have been employed.

Results and Discussions

The findings provided important information about the associations between the presence of type 2 diabetes mellitus (T2DM) and different atherosclerosis-related biomarkers. Numerous studies have demonstrated the intricate relationship between cardiovascular health and diabetes [19, 20], showing notable variations in oxidized low-density lipoprotein (LDL) levels across people with various T2DM statuses. The group of individuals without diabetes had lower levels of oxidized low-density lipoprotein (LDL), suggesting that oxidized LDL plays a significant role in the development of coronary artery disease more quickly. The fundamental elements of Oxidize statistics are displayed in Table 2 for each of the clusters.

Table 2: The Element Oxidize-"'s Fundamental Statistic

	N	Mean	Std. Deviation	95% Confidence Interval for Mean		Minimum
				Lower Bound	Upper Bound	
Group 1	79	76.61701	28.571851	70.21727	83.01676	2.770
Group 2	60	51.42147	10.875049	48.61214	54.23079	29.000
Group 3	81	84.39179	56.727639	71.84828	96.93530	40.000
Total	220	72.60803	40.966877	67.16456	78.05151	2.770

The mean value of group 1 is 76.67 while the standard deviation is 28.57 and the confidence interval for the mean ranges from 70.22 to 83.02. whereas, in group 2 the mean value of group 2 is 84.39 while the standard deviation is 10.88, and the confidence interval for the mean ranges from 71.85 to 96.94. In group 3 the mean value is 84.39, while the standard deviation is 56.73, and the confidence interval for the mean ranges from 71.85 to 96.94. The results obtained from the analysis provide insight into central tendency and precision related to the variables across different groups. Furthermore, the ANOVA analysis confirmed the variation in oxidized LDL levels among T2DM status groups, this shows the influencing of oxidative processes with other related factors significantly in individuals with diabetes contributing to accelerated atherosclerosis as shown in Table 3. The analysis showed that there are significant differences in the mean levels of "Oxidize" across the groups as the F-statistic is 13.046, and the p-value is < 0.001 which is less than the significance level 0>05.

Table 3: ANOVA Analysis

ANOVA					
	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	39449.329	2	19724.664	13.046	.000
Within Groups	328095.083	217	1511.959		
Total	367544.412	219			

Table 4: The Correlation Analysis

		Oxidize	Troponin	F.B.S	Triglyceride	Cholesterol
Oxidize	Pearson Correlation	1	.059	.186**	.248**	.248**
	Sig. (2-tailed)		.384	.006	.000	.000
	N	220	220	220	220	220
Troponin	Pearson Correlation	.059	1	.213**	.225**	.203**
	Sig. (2-tailed)	.384		.002	.001	.002
	N	220	220	220	220	220
F.B.S	Pearson Correlation	.186**	.213**	1	.281**	.264**
	Sig. (2-tailed)	.006	.002		.000	.000
	N	220	220	220	220	220
Triglyceride	Pearson Correlation	.248**	.225**	.281**	1	.885**
	Sig. (2-tailed)	.000	.001	.000		.000
	N	220	220	220	220	220
Cholesterol	Pearson Correlation	.248**	.203**	.264**	.885**	1
	Sig. (2-tailed)	.000	.002	.000	.000	

	N	220	220	220	220	220
HDL	Pearson Correlation	-.153*	-.237**	-.326**	-.569**	-.492**
	Sig. (2-tailed)	.023	.000	.000	.000	.000
	N	220	220	220	220	220
VLDL	Pearson Correlation	.244**	.229**	.285**	.979**	.877**
	Sig. (2-tailed)	.000	.001	.000	.000	.000
	N	220	220	220	220	220
LDL	Pearson Correlation	.246**	.197**	.290**	.819**	.933**
	Sig. (2-tailed)	.000	.003	.000	.000	.000
	N	220	220	220	220	220

Furthermore, as seen in Table 4, the correlation analysis verified a substantial relationship between the presence of type 2 diabetes and several cardiovascular biomarkers, including troponin, F.B.S., triglycerides, cholesterol, HDL, and VLDL. This relationship demonstrates the variables that affect diabetic cardiovascular problems and supports the idea of obtaining a wide panel of biomarkers for risk assessment. Table 4 shows a positive correlation between Oxidize" and "Triglyceride" where ($r = 0.248$, $p < 0.01$), this indicates that Triglyceride increases along with Oxidize increment, whereas, a positive correlation has been noticed between Oxidize" and "HDL" ($r = -0.153$, $p < 0.05$) resulting in that higher levels of "HDL" are associated with lower levels of "Oxidize." Strong correlations ($|r| > 0.5$) are observed between "Triglyceride" and "Cholesterol," "Triglyceride" and "VLDL," "Cholesterol" and "LDL," and "Cholesterol" and "VLDL," suggesting strong associations between these variables. In addition to these analyses, a regression analysis also revealed that oxidized LDL levels are influenced by several variables, including age, cholesterol, triglycerides, F.B.S., and LDL. These predictors shed light on the complex features of diabetic atherosclerosis, which include dysregulated metabolism, aberrant lipid profiles, and the need to closely monitor blood sugar levels. According to a different predictor variable, each of the following factors can be used to predict "Oxidize" levels: troponin, age, F.B.S., LDL, HDL, VLDL, triglycerides, and cholesterol.

Table 5: The P-Values That Correspond with the Regression Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	Sig.
		B	Std. Error	Beta	
1	(Constant)	30.342	41.675		.467
	Age	-.365	.485	-.052	.452
	LDL	.104	.248	.086	.674
	VLDL	-.157	.880	-.060	.859
	HDL	.084	.388	.020	.829
	Cholestreol	.048	.235	.050	.837
	Triglyceride	.088	.181	.167	.628
	F.B.S	.165	.087	.138	.059
	Troponin	-5.899E-5	.000	-.009	.896

As shown in Table 5, the p-values that correspond with the regression coefficients are responsible for ascertaining whether or not each predictor variable exhibits statistical significance. Given that the F.B.S. coefficient is 0.165, the beta coefficient for "oxidize" is 0.138. This means that the projected increase in "oxidize" levels is 0.138 units in a standardized variable or 0.165 units for every standard feature unit increase in F.B.S. The "Oxidize" level and F.B.S. may be somewhat related, according to the computed p-value of 0.059, even if this link is not statistically significant at the standard significance level of 0.05. Our regression model's R square value of 0.083 indicates that the remaining variance of"oxidize" concentrations and the factors included in the predictor variables used in the regressions can account for 8.3% of the explained variance as shown in the Table 6. The Modified Regression Variation Sum (0.049) clarifies the uncertainty of the actual future while making up for the quantity of model predictions. Conversely, the F-statistic value of 2.401 is employed as a means of determining the statistical significance of the predictor variable model.

Table 6: Regression Model's

R	R Square	Change Statistics

Model			Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	Df
1	.289[a]	.083	.049	39.957378	.083	2.401	8

Conclusion

The data collection and analysis have provided valuable insights relating to the connection between twice-two diabetes and blood biomarkers that signal the progressing atherosclerotic process. The implementation of the longitudinal cohort study design detailing oxidized LDL levels between different T2DM status cohorts such as those with myocardial infarction (MI) both with and without diabetes, as well as those without diabetes is necessary. The study resulted in the discovery of highly significant links between T2DM status and specific cardiovascular disease markers of Troponin, fasting blood sugar (F.B.S.), triglycerides and cholesterol, HDL, and VLDL. Based on this research, patients with myocardial infarction who have diabetes mellitus, especially those who do not have controlled diabetes, showed a higher degree of oxidized LDL compared to those who have no diabetes or those whose diabetes is well controlled. Further, there is known to exist a statistically significant correlation between a rise in LDL oxidization and the levels of other biomarkers such as Troponins, F.B.S., triglycerides, cholesterol, HDL, and VLDL. Regression analysis revealed age as one of the major determining factors of LDL-C oxidation, other variables, such as LDL-C, fructosamine, triglycerides, and cholesterol may be among those taking part in the development of diabetic atherosclerosis.

Jointly, this data reinforces the necessity of close monitoring of cardiovascular biomarkers in people with type 2 diabetes and previously experienced myocardial infarction, because this way, cardiovascular risks can be assessed more precisely and effectively. This further increases the need for more research on uncovering the underlying cause as well as potential interventions for managing these risks.

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