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# The Importance of Biochemical Markers in Diagnosing, Managing and Predicting Diabetes Mellitus

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## Abstract

Diabetes is a widespread and intricate metabolic illness marked by persistent high blood sugar because of flaws in insulin production, insulin activity, or both. Current treatments don't address the disease's complete development, and management often fails because individual traits vary. People may experience either a metabolic pathway becoming inactive or over stimulated, which can lead to different levels of blood sugar control.

Biochemical markers of this condition are very important for early detection, management, and diagnosis because clinical symptoms alone are often not reliable. The focus of treatment should be on results, including supporting mental health care. Diabetes is growing around the world, especially in developing regions where healthcare access is spotty. Therefore, investigating how precision medicine, along with biometrics and biochemical data, can augment existing methods is of value. These sources of data could improve health outcomes and reduce future problems.

Samples were taken from patients from several hospitals in Diyala Governorate: Baquba Teaching Hospital, Al-Zahraa Hospital, and Al-Khalis Hospital. This investigation included 90 patients with various forms of diabetes (T1DM, T2DM, and gestational), aged 25 to 70, with a male to female ratio of 38/52. The distribution of diabetes types was as follows: T2DM (47/90), T1DM (17/90), and gestational diabetes (26/90). Sample collection took place over 10 months.

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This investigation sought to examine diabetes cases and the function of biochemical markers (HbA1c, LDL, and triglycerides) along with biometric variables (body weight and BMI) in creating specific treatments. The results showed better blood sugar control and lowered heart issue risk. Treatment plans considering individual biochemistry helped lower blood sugar and reduce body inflammation. Doctors may improve patient care by creating plans based on individual needs, rather than using a standard approach. The findings suggest that personalized medicine can improve the treatment of diabetes patients, reduce side impacts, and improve overall well-being.

**Keywords:** biomarker Analysis, T1DM, T2DM, Gestational diabetes, Insulin resistance, HbA1c.

## Introduction

Diabetes is a big health issue worldwide, impacting tons of people no matter where they're from or how old they are [1] [2]. It's basically high blood sugar [3], usually because the body isn't making or using insulin right. This causes blood sugar to go up as people get older, especially if they don't eat well or get enough exercise [4]. Type 2 diabetes is super common, making up about 90% of all cases. It puts a strain on healthcare everywhere, so we need to find better ways to deal with it [5]. Diabetes comes in different types, and they all work a bit differently in the body and show up with varied symptoms [6] [3], For instance, type 1 is considered autoimmune, where the body attacks cells in the pancreas. Type 2, on the other hand, often runs in families and is tied to how bodies handle insulin, possibly due to things in the surroundings. [7]. Then there's gestational diabetes, which pops up during pregnancy and can be risky for the mom. Because everyone's health case is unique and diabetes varies, custom treatment using biomarkers turns crucial when doing this kind of medical researc [8] [9]. Biomarkers can pinpoint what's really going on with diabetes, which helps us find different groups among patients and come up with the right treatments [10] [11]. Putting biomarker tests into everyday practice has really changed how we handle diabetes [12] [13]. The old way of doing things, where we just look at one thing and ignore everything else like how quickly the disease is changing in someone, other health issues they have, and how they react to treatment usually doesn't work very well. Besides that, some ways that most doctors do things, like checking

particular biomarkers for patients that were already picked beforehand, often don't give the best results [14] [15]. On the other hand, you can create treatments that are based on someone's health profile, like using anti-inflammatories when C-reactive protein is high [16], GLP-1 receptor agonists and SGLT2 inhibitors should lower body-wide inflammation and help control blood sugar, especially for people who already have risks for heart problems and metabolic issues [17][18]. It's super important to check things like HbA1c (for blood sugar control over time), LDL (for heart risk), and triglycerides (for metabolic health) so that therapies are a good fit [19] [20][21]. Also, body weight and BMI can really tell you about obesity risks, which is important for creating the right diabetes plan for each person [22].

## Material and Methods

**Patient's selection:**

Diabetic patients were randomly selected, taking into account ethnic diversity. Data were collected from biometric data, all medical systems, and various outcomes. Select from a variety of games, genders, and diabetes types.

**Determination of the biochemical parameters:**

The study primarily focused on key biochemical markers related to blood sugar control, pancreatic function, lipid metabolism, autoimmune diseases, and inflammation. Glycated hemoglobin (HbA1c) was measured to assess long-term blood sugar control [19].

C-peptide levels provided a complete and clear view of the activity of the remaining pancreatic β-cell. [20], Special attention was paid to distinguishing between type 1 and type 2 diabetes.

Triglycerides and low-density lipoprotein cholesterol were evaluated as indicators of dyslipidemia and cardiovascular disease risk. [21] [22]. Anti-GAD antibodies served as autoimmune markers to confirm T1DM diagnosis [23] [24]. Additionally, emerging inflammatory biomarkers such as visfatin and serum amyloid A (SAA) were Modified included to explore their potential role in diabetes-related metabolic and inflammatory pathways [25][26]. Data were obtained from patient medical records, encompassing routine lab tests and specialized immunoassays.

**Types of treatment and their Biochemical role:**

Treatment Role: The treatment role was divided by the type of treatment prescribed, according to the patient's medical records, respectively, with some specific interventions related to (lifestyle modification through diet quality control, weight loss, exercise), and some patterns leading to weight loss due to the type of medication originally prescribed. These were some of the medications documented in the patients' records. Which are:

Metformin: to improve insulin sensitivity [27] [28]. GLP-1 and SGLT2 receptor blockers: to help with weight loss and control blood sugar levels [29] [30].

Insulin therapy: for T2DM diabetes and some cases of gestational diabetes; DPP-4 inhibitors: for patients with moderate hyperglycaemia [31] [32].

Statins: to reduce cardiovascular risk in patients with elevated LDL levels [33].

Anti-inflammatory agents: for patients with elevated CRP or IL-6 levels [34] [35].

Lifestyle modifications:

Dietary interventions: focused on reducing calories and improving macronutrient distribution.

Exercise programs: aimed at improving insulin sensitivity and weight control.

**Outcome Assessment**

The baseline follow-up period for clinical outcomes was 8–10 months. The main outcome measures were: Glycemic control: A decrease in glycated hemoglobin (HbA1c) of at least 1.0% was considered statistically significant. Weight loss: This was documented in the majority of patients receiving GLP-1 receptor agonists and SGLT2 inhibitors. Improvements in triglyceride and low-density lipoprotein (LDL) cholesterol levels were a measure used to indicate reduced cardiovascular risk.

**Data Analysis:**

Quantitative analysis: Outcome data were analyzed for patients who demonstrated significant improvement in glycated hemoglobin (HbA1c) and other treatment parameters. Predictive factors were identified using biomarkers and a wide range of therapeutic interventions. Qualitative analysis: Most observations based on individual responses have been recorded, especially in complex cases, such as high-risk, difficult-to-control type 2 diabetes. This retrospective analysis included 90 diabetic patients, using biomarkers such as glycated

hemoglobin (HbA1c), peptide, triglycerides, and anti-GAD antibodies, as well as new markers such as visfatin and serum amyloid A. Treatments used were categorized as biomarkers, interventions for health care (e.g., metformin, GLP-1 therapy, and therapeutic agents), and lifestyle modifications. Results of most tests, such as HbA1c, weight loss, and patient accountability, were recorded over a 10-month period.

**Statistical Analysis**:

Statistical Methods Used:

1. Paired Sample t-Test:

Purpose: To compare the mean values before and after treatment within the same group of patients.

Application:

It is applied to HbA1c, weight, BMI, LDL cholesterol, and triglyceride levels (as shown in Tables 1, 2, and 3).

This test is used to assess whether the mean difference before and after treatment is statistically significant.

Significance threshold: A p-value < 0.05 was considered statistically significant.

Rationale: The paired t-test is ideal when assessing the effect of an intervention on the same subjects over time.

2. Descriptive Statistics:

Mean ± Standard Deviation (SD):

It was designed to describe the central tendency and variance of each parameter.

It is useful for interpreting the average effectiveness of each treatment.

3. Subgroup Analysis:

This study was conducted to evaluate the differences between the subtypes of diabetes (T1DM, T2DM, and GDM). This study provided a deeper understanding of the effectiveness of treatment in various clinical settings.

4. Clinical significance vs. statistical significance:

While statistical significance ($p < 0.05$) confirms that changes are unlikely to be due to chance, clinical significance was also considered by setting improvement thresholds.

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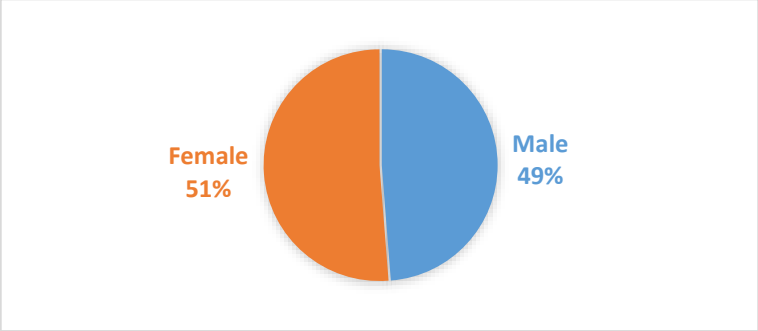
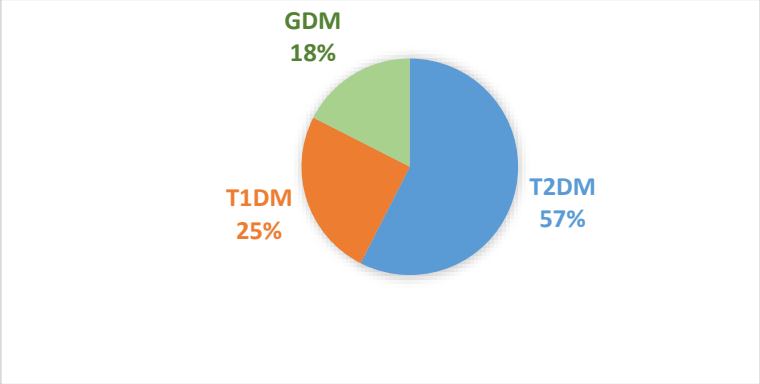
## Results and Discussion




**Figures 1:** Distribution of the cases enrolled in the present study by gender.




**Figures 2:** Distribution of the cases enrolled in the present study By Type of Diabetes.

**Table 1:** HbA1c level before and after Treatment

| Treatment type | HbA1c (%) before treatment | HbA1c (%) after treatment | p-value | **Notes** |
|---|---|---|---|---|
| Metformin | 9.2 ± 1.1 | 7.7 ± 0.9 | <0.05 | 80% of GDM patients reached HbA1c < 6.0% |
| GLP-1 Receptor Agonists | 9.0 ± 1.3 | 7.0 ± 1.1 | <0.05 | Mean HbA1c reduction: **1.5%** |
| SGLT2 Inhibitors | 9.1 ± 1.2 | 7.3 ± 1.0 | <0.05 | Mean HbA1c reduction: **1.5%** |
| Insulin Therapy | 9.4 ±1.4 | 7.8 ± 1.3 | <0.05 | Used in T1DM and GDM; 80% of GDM cases reached HbA1c < 6.0% |
| Lifestyle Modifications | 8.8 ± 1.0 | 7.4 ± 1.1 | <0.05 | Effective in early-stage T2DM |
| Combination Therapy | 9.3 ± 1.3 | 7.2 ± 1.0 | <0.05 | Often used in T2DM with obesity/metabolic syndrome |

**Controlling blood sugar levels Reducing HbA1c:**

Overall improvement: 85% of patients achieved a clinically significant reduction in HbA1c of at least 1.0%.

**Subtype trends:**

Patients taking GLP-1 receptor antagonists or SGLT2 inhibitors improved the most, with a mean reduction in HbA1c of 1.5%. Gestational diabetes mellitus (GDM) patients treated with metformin or insulin had normal HbA1clevelsbelow 6.0% in 80% of cases (Table 1).

**Table 2:** Weight and BMI before and after treatment

| Treatment type | Weight Before (kg) | Weight After (kg) | p-value | BMI Before (kg/m²) | BMI After (kg/m²) | p-value |
|---|---|---|---|---|---|---|
| Metformin | 85 ± 10 | 82 ± 9 | <0.05 | 32 ± 3.0 | 30.9± 2.8 | <0.05 |
| GLP-1 Receptor Agonists | 88 ± 12 | 82 ± 11 | <0.05 | 33 ± 32 | 31 ±3.1 | <0.05 |
| SGLT2 Inhibitors | 87 ± 11 | 83 ± 10 | <0.05 | 32.5± 2.8 | 31± 2.7 | <0.05 |
| Lifestyle Modifications | 84 ± 8 | 81 ± 7 | <0.05 | 31 ± 2.7 | 30± 2.6 | <0.05 |

**Weight Loss**

Patients on GLP-1 receptor agonists or SGLT2 inhibitors experienced the most significant weight loss, with an average of 5-7% reduction in base line weight(table-2) [30] [29]. Weight loss was particularly pronounced in T2DM patients with obesity, contributing to improved insulin sensitivity and cardiovascular risk profiles, (Table 2).

**Table 3:** Lipid profile levels (LDL and triglycerides before and after treatment).

| Treatment type | LDL Before (mg/dL) | LDL After (mg/dL) | p-value | Triglycerides Before (mg/dL) | Triglycerides After (mg/dL) | p-value |
|---|---|---|---|---|---|---|
| Metformin | 140 ± 20 | 120 ± 18 | <0.05 | 180 v 25 | 155 ± 20 | <0.05 |
| GLP-1 Receptor Agonists | 145 ± 22 | 115 ±19 | <0.05 | 185 ± 30 | 150 ± 22 | <0.05 |
| SGLT2 Inhibitors | 142 ± 18 | 118 ± 17 | <0.05 | 182± 28 | 160 ± 25 | <0.05 |
| Insulin Therapy | 138 ± 21 | 125 ± 20 | <0.05 | 175 ± 22 | 165 ±20 | <0.05 |

**Reducing Cardiovascular Risk**

Triglycerides and LDL cholesterol:Two studies have shown that 70% of patients with high triglyceride levels (>175 mg/dL) achieved at least a 20% reduction when using GLP-1 receptor agonists or statin therapy, Table-3 [21] [36] . LDL cholesterol levels also improved significantly

in patients taking statins, with a median reduction of 25 mg/dL as shown in table 3. This study demonstrates the effectiveness of biomarker-based precision medicine in improving outcomes for patients with different types of diabetes by aligning treatment strategies with individual biochemical profiles [33] [37]. The reduction in systemic inflammation was strongly associated with improved glycaemic control, suggesting a clear link between inflammatory processes and insulin resistance. Markers such as C-reactive protein (CRP) and interleukin-6 (IL-6) decreased significantly in patients receiving anti-inflammatory therapies, such as GLP-1 receptor agonists and SGLT2 inhibitors, supporting their dual role in managing both glucose metabolism and cardiovascular risk. In patients with T1DM, the presence of GAD antibodies has been shown to guide the application of immunotherapy in combination with insulin, which improves glucose levels and stabilizes them, significantly reducing insulin dependence [23] [24] [38]. In the same context, C-peptide levels have been used to assess the function of remaining β-cell, which is an effective way to differentiate between type 1 and type 2 diabetes and select the appropriate treatment protocol.

The use of GLP-1 receptor agonists, SGLT2 inhibitors, and statins has led to significant improvements in lipid profiles in type 2 diabetes patients, particularly those with obesity and elevated triglyceride and low-density lipoprotein cholesterol levels, contributing to a reduced risk of cardiovascular disease. These patients also experienced weight loss and improved glycemic control, demonstrating the multiple benefits of these medications. [27] [28].

Studies show that drugs like metformin and insulin help women with gestational diabetes. This is key to preventing problems during pregnancy because these drugs help blood sugar and HbA1c levels get back to normal quickly. HbA1c is a dependable way to measure long-term blood sugar control, and the treatment worked for most patients (85%) by bringing their levels down. Also, researchers saw that certain markers in blood, like visfatin and SAA, went up in some type 2 diabetes patients who were very resistant to insulin. This could point to new ways to treat the disease. These markers could help doctors find patients who are more likely to have issues and make treatments specific to the patient, like anti-inflammatory or metabolic treatments. Even though the treatment works in most cases, it doesn't help about 15% of patients.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This might be because patients don't stick to the treatment plan or because they have other health problems. This means that teaching patients about their condition and keeping an eye on them long-term is very important for treatment. The main point is that diabetes treatment should be made to fit each patient's unique markers for a better way to handle this tricky disease.

## Conclusion

This study shows that using biomarkers to guide treatment choice improves diabetes care. Specific biomarkers, like C-peptide and anti-GAD antibodies, are helpful for telling the difference between type 1 and type 2 diabetes. Proper treatment plans based on glycated hemoglobin (HbA1c) levels lead to better blood sugar. Treatments aimed at triglycerides and low-density lipoprotein cholesterol lower the chance of heart issues. Checking inflammatory markers, such as visfatin and serum amyloid A (SAA), shows how much inflammation is in the body, which helps in picking good anti-inflammatory treatments. Most patients had better blood sugar, cholesterol, and less inflammation. About 15% didn't get much better, mostly because they didn't stick to their treatment. Future work includes looking into new biomarkers, using AI to improve custom care, and doing long-term studies to see if the treatments keep working.

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**Conflict of Interest:** The authors have no conflict of interest.

**Ethical Clearance** The samples were gained according to Local Research Ethics Committee Approval in the College of Science, University of Diyala, No. 25 EC-62 in 9/2/2025

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