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EVALUATION OF LACTATE DEHYDROGENASE ENZYME AND SOME BIOCHEMICAL VARIABLES IN THE BLOOD OF PEOPLE WITH TYPE 1 DIABETES AND TYPE 2 DIABETES IN SALAH AL-DIN GOVERNORATE

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June 2022

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ABSTRACT

EVALUATION OF LACTATE DEHYDROGENASE ENZYME AND SOME BIOCHEMICAL VARIABLES IN THE BLOOD OF PEOPLE WITH TYPE 1 DIABETES AND TYPE 2 DIABETES IN SALAH AL-DIN GOVERNORATE

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The present research attempted to compare diabetic patients with healthy controls in terms of LDH activity and other characteristics. Patients with diabetes mellitus (DM) of both types 1 and 2 were included in the study, as were 40 healthy individuals (the "control" group). All of the people are between the ages of 40 and 75. From October 2021 to January 2022, a number of hospitals in Kirkuk, Iraq, participated in the research. The results showed the average age of control group is 31.23 ±1.27, while the average age of diabetes type I group is 41.62 ±1.79. The average age of diabetes type II group is 36.15 ±2.09. BMI in control group is 23.99 ±1.76 and in diabetes (type I and II) group is 28.72 ±1.12 and 27.05 ±0.87 respectively. Lipid profile showed significant ($P<0.05$) increased and decreased in between studied groups. Patients with diabetes types I and II had significantly higher levels of uric acid, LDH, and insulin than those in the control group (P 0.05). Patients with diabetes type I and type II exhibited a substantial (P 0.05) drop in serum salt and magnesium levels compared to the control group. It's concluded that the both types of diabetes mellitus lead to significant ($P <0.05$) differences in the studied parameters.

2022, 43 pages

Keywords: Lipid profile, Uric acid, Magnesium, Sodium, LDH

ÖZET

SALAH AL-DİN VALİLİKİNDE TİP 1 DİYABET VE TİP 2 DİYABET OLANLARIN KANINDAKİ LAKTAT DEHİDROJENAZ ENZİMİ VE BAZI BİYOKİMYASAL DEĞİŞKENLERİN DEĞERLENDİRİLMESİ

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Bu araştırma, diyabetik hastaları LDH aktivitesi ve diğer özellikler açısından sağlıklı kontrollerle karşılaştırmaya çalıştı. Hem tip 1 hem de tip 2 diyabetli (DM) hastalar ve 40 sağlıklı birey ("kontrol" grubu) çalışmaya dahil edildi. Tüm insanlar 40 ila 75 yaşları arasında. Ekim 2021'den Ocak 2022'ye kadar Irak'ın Kerkük kentindeki bir dizi hastane araştırmaya katıldı. Sonuçlar, kontrol grubunun yaş ortalamasının 31,23 ±1,27 olduğunu, diyabet tip I grubunun yaş ortalamasının ise 41,62 ±1,79 olduğunu gösterdi. Tip II diyabet grubunun yaş ortalaması 36,15 ±2,09'dur. BMI kontrol grubunda 23.99 ±1,76, diyabet (tip I ve II) grubunda sırasıyla 28,72 ±1,12 ve 27,05 ±0,87'dir. Lipid profili, çalışılan gruplar arasında anlamlı (P<0.05) artış ve azalma gösterdi. Tip I ve II diyabetli hastalarda ürik asit, LDH ve insülin düzeyleri kontrol grubundakilere göre anlamlı olarak daha yüksekti (P 0,05). Tip I ve tip II diyabetli hastalar, kontrol grubuna kıyasla serum tuzu ve magnezyum seviyelerinde önemli (P 0,05) bir düşüş sergilemiştir. Her iki diabetes mellitus tipinin de çalışılan parametrelerde önemli (P <0,05) farklılıklara yol açtığı sonucuna varılmıştır.

2022, 43 sayfa

Anahtar Kelimeler: Lipid profili, Ürik asit, Magnezyum, Sodyum, LDH

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Rojyan Dawood Obaid OBAID

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CONTENTS

LIST OF SYMBOLS

μL	Microliter
g	Gram
mg/dL	Milligrams per decilitre
mL	Milliliter
mM	Millimeter
nm	Nanometer

LIST OF ABBREVIATIONS

DKA	Diabetic ketoacidosis
DM	Diabetes mellitus
EDTA	Ethylenediaminetetraacetic acid
FG	Fasting glucose
HbIAC	Glycation hemoglobin
HDL	High density lipid
HLA	Human leukocyte antigen
LDH	Lactate dehydrogenase
LDL	Low density lipid
Mg	Megnesium
MHC	Major histocompatibility complex
MODY	Maturity-onset diabetes of the young
Na	Sodium
NAFLD	Nonalcoholic fatty liver disease
SST	Serum separator tubes
TC	Total cholesterol
TGs	Triglyceride
VLDL	Very low density lipid

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1. INTRODUCTION

Blood sugar levels in people with diabetes mellitus (DM) tend to be elevated. Young persons and those in middle age or older who have a chronically elevated blood sugar level as a consequence of poor lifestyle and food choices are at risk for type 1. Because type 1 and type 2 etiologies are so diverse, each type has its own set of etiologies, clinical characteristics, and treatments (Artasensi *et al.* 2020).

The damage of pancreatic cells, which is often induced by an autoimmune mechanism, is the hallmark of T1DM. As a result, cells are killed totally, and insulin levels are either non-existent or extremely low.

In the early phases of T2DM, insulin functional deficiencies may be caused by an insulin-insulin sensitivity mismatch. Insulin resistance may result from a variety of factors, not all of which are related to obesity (Wang *et al.* 2018).

Even though there is no clear cutoff threshold for hyperglycemia in this context, it is common to refer to glucose levels over 180 mg/dL as hyperglycemic. Although polydipsia and other symptoms associated with high glucose levels (more than 250 mg/dL) are possible, the end result is unknown.

By elevating fatty acids and proinflammatory cytokines, insulin resistance increases fat breakdown and hinders glucose delivery. Hyperglycemia is caused by an increase in the hormone glucagon as a consequence of impaired insulin sensitivity or synthesis.

Insulin, the most modern method of managing blood sugar, may help to keep glucose levels stable. Both type 1 and type 2 diabetes are diagnosed in diabetics (T2DM). Exogenous insulin may turn glycogen into fat accumulation in the liver (Freeland and Farber 2016).

1.1 The Aim of the Thesis

Investigating LDH enzyme activity in the blood of DM patients compared to healthy indivduals.

Patients with type 1 and type 2 diabetes will be used to collect 100 samples. For those between the ages of 25 and 55. There will be a total of three divisions:

The first group: 40 individuals without the disease.

The second group: 37 individuals with the disease for the age group from 25 to 35 years.

The third group: 63 individuals with the disease for the age group from 35 to 55 years

Listed below are the tests that will be carried out in line with the manufacturer's method of operation (kit).

- Insulin
- Serum LDL
- Uric acid
- Serum TC
- Serum TG
- serum HDL
- Magnesium
- Sodium
- LDH

2. LITERATURE REVIEW

2.1 Diabetes Melitis

DM is formed from the Greek terms diabetes (siphon) and mellitus (sweet). The sweetness of urine in this disease was discovered by ancient peoples. The significance of the pancreas in the etiology of diabetes was discovered by Mering and Minkowski. At Toronto University, Banting, Best, and Collip isolated insulin from the pancreas of cows, paving the way for its use as a diabetes treatment. Diabetes, on the other hand, is one of the most prevalent long-term conditions in the world (Artasensi *et al.* 2020).

DM is a metabolic condition in which blood glucose levels are unusually high. T1DM, T2DM, MODY, neonatal diabetes, gestational diabetes, and secondary diabetes induced by endocrinopathies, steroids, and other causes are among the most common types of diabetes. T1DM and T2DM are the two most frequent types, both of which are caused by insufficient insulin secretion (type I) or action (type 2), respectively (type 2). Type 1 affects children and teens, while type 2 affects adults in their middle and late years who have chronic hyperglycemia as a consequence of poor dietary and lifestyle choices. Because the etiologies of type 1 and type 2 are so dissimilar, each type has its own set of etiologies, clinical features, and treatments (Wang *et al.* 2018).

2.1.1 Epidemiology

One out of every eleven adults in the globe suffers from diabetes (90 percent T2DM). T1DM develops over time, peaking between the ages of 4-6 years and then again between the ages of 10-14 years (Felner *et al.* 2005). More than a quarter of all children under 10 years of age show up. People under the age of 20 have a 2.3/1000 chance of developing the disease. In the incidence of T1DM in children, there are no obvious gender differences. In some cultures, such as European older guys (>13 years), they are more prone than females (3/2 male/female ratio) to acquire T1DM (Gale and Gillespie 2001).

T1DM is becoming more common over the world (Mamoulakis, Galanakis *et al.* 2003). T1DM rates in the United States have risen by about 2% each year, with rates among Hispanics being higher (Vehik *et al.* 2007). The precise cause for this pattern is unidentified.

In spite of the rise in T2DM in adolescents, the disease often develops later in life. Diabetes type 2 (T2DM) affects around 9% of the US population, although about 25% of those afflicted are 65 years or older. T2DM affects African-Americans, Native Americans, and Hispanics with a rate that is 2 to 6 times higher than that of white Americans in the United States (Harris *et al.* 1998).

2.1.2 Classification and pathophysiology

Additionally, Langerhans cells produce insulin and glucagon in the pancreas. In reaction to the glucose environment, cells are constantly adjusting the amounts of hormone expression. If insulin and glucagon levels are out of whack, the glucose levels are unbalanced. Insulin insufficiency and/or impaired insulin activity are the main causes of diabetes mellitus (DM) (insulin resistance).

Beta cells in the pancreas are destroyed by an autoimmune response in T1DM. As a consequence, insulin production is either nonexistent or exceedingly low (Wang *et al.* 2018).

With T2DM, insulin dysfunction is produced by an imbalance in the amounts of insulin and the sensitivity of the pancreas, which leads to an insulin functional deficit. Obesity and old age are the most common causes of insulin resistance, but it may be caused by a variety of other factors as well.

The genetic makeup of the two kinds is a substantial risk factor. Multiple loci that signal DM risk have been discovered as the human genome has become more known. T1DM risk has been related to MHC and HLA polymorphisms (Rajaei *et al.* 2019).

Type 2 diabetes (T2DM) is characterized by a more complex interplay between environmental factors and inherited traits. T1DM and T2DM seem to be more genetically different. At least one parent of T2DM sufferers has the condition (Klein *et al.* 1996).

A genome-wide association study (GWAS) has connected TCF7L2 to an elevated risk of Type 2 Diabetes Mellitus (T2DM) (Saxena *et al.* 2007). WFS1, JAZF1, NOTCH2, and KCNQ1 are among the additional genes associated with T2DM development (Yasuda *et al.* 2008).

Diabetic people are at risk for developing hyperglycemia. Diabetic complications are confounded by the fact that a wide range of causes may be at play. All that hyperglycemia does is limit insulin production by impairing pancreatic cell function. Hyperglycemia creates a vicious cycle, and the outcome is impaired metabolic function. Hyperglycemia is defined as blood glucose concentrations more than or equal to 180 mg/dL; however, there is no clear cutoff point due to the variety of mechanisms at play. When the blood glucose level is over 250 mg/dL, symptoms such as polyuria and polydipsia are anticipated to develop, however the impact is variable.

Fatty acids and proinflammatory cytokines rise as a result of insulin resistance. This inhibits glucose delivery and causes fat breakdown. Hyperglycemia is caused by a deficiency in insulin sensitivity or production.

2.1.3 Diagnosis of diabetes melites

In addition to HbA1c testing, fasting glucose levels are useful in diagnosing whether or not a person has T2DM. A GTT (glucose tolerance test) may be used to measure fasting glucose levels and the serum response to an OGTT (an oral glucose tolerance test). If your fasting blood glucose level falls between 100-125 mg/dL and your 2-hour post-OGTT glucose level falls between 140-200 mg/dL, you have Type 2 Diabetes (T2DM) (Association 2010).

Few laboratory tests are useful in the management of diabetes. Hyper- and hypoglycemia tendencies may be detected by using a home glucose test. Over a three-month period, the HbA1c test determines the level of glycation produced by hyperglycemia. Diabetic nephropathy may be detected early on with the use of a urine albumin test. Because diabetics are predisposed to cardiovascular disease, it makes sense to do serum lipid testing as soon as possible once a patient is diagnosed. A increased risk of hypothyroidism necessitates annual thyroid-stimulating hormone testing, according to some experts (Association 2010).

2.2 Lifestyle, Genetics, and Medical Conditions

Type 2 diabetes is mostly caused by a person's lifestyle and genetics. Type 2 diabetes has been linked to a variety of factors, including one's everyday lifestyle. Inactivity may be caused by a variety of things, including smoking cigarettes and drinking too much alcohol (Hu *et al.* 2001). Obesity is estimated to be the root cause of type 2 diabetes in 55% of patients. Children and adolescents with type 2 diabetes are becoming ever more common as juvenile obesity has increased over the last few decades (Barlow *et al.* 2007).

Environmental pollutants may be to blame for the current increase in type 2 diabetes prevalence. Bisphenol A, a molecule present in a broad range of plastics, has been suggested as a possible cause of type 2 diabetes (Lang *et al.* 2008). Type 2 diabetes is more likely to run in your family (particularly in first-degree relatives) because of the close genetic ties between the two diseases. About a quarter of patients with diabetes have a family history of the condition, and identical monozygotic twins show almost complete concordance in their genetic makeup (Rother 2007).

Type 2 diabetes has been associated to a variety of genes, including TCF7L2, PPARG, FTO, KCNJ11, NOTCH2, WFS1, CDKAL1, IGF2BP2, SLC30A8, JAZF1, and HHEX. the expression of the proglucagon gene, and hence the production of glucagonlike peptide-1, is controlled by the potassium inwardly rectifying channel subfamily J member 11, which encodes the islet ATP-sensitive potassium channel Kir6.2

(McCarthy *et al.* 2010). Type 2 diabetes risk is passed down via families in large part. Maturity-onset diabetes of the young (MODY) accounts for up to 5% of all cases of diabetes (Camastra *et al.* 1999).

Type 2 diabetes may be caused or exacerbated by a broad variety of medical issues. Elevated cholesterol (combined hyperlipidemia) and metabolic syndrome (also known as Syndrome X or Reaven's syndrome) are two such conditions. In addition to Cushing's disease and medication-induced hyperthyroidism, additional causes include chronic pancreatitis or cancer, as well as hyperthyroidism (Powers *et al.* 2008). Diabetes is more common among the elderly, those with sedentary lifestyles, and those who consume a high-fat diet (Lovejoy 2002).

2.3 Goals of Management

The most essential element of preventing diabetes in susceptible people or the broader community is primary prevention. – Regular exercise has the potential to both prevent and control the onset of type 2 diabetes. In prospective cohort studies, physical activity has been shown to protect against type 2 diabetes, independent of other risk factors (Helmrich *et al.* 1991, Ross *et al.* 2000).

Type 2 diabetes treatment and control relies heavily on dietary and lifestyle changes. Weight reduction, better glycemic control, and a reduced risk of coronary heart disease (CHD), which is responsible for 70 to 80 percent of diabetic-related deaths, are the key goals of dietary and lifestyle changes for people with type 2 diabetes. (National Institutes of Health (1995)).

Insulin hormone replacement therapy is used to treat type 1 diabetes, whereas dietary and lifestyle changes are used to treat type 2. When diet, weight loss, exercise, or oral drugs fail to control blood glucose levels, insulin is administered to do so. The use of oral hypoglycemics may be beneficial to diabetics with type 2 diabetes. Sulphonylureas, biguanides, alpha glucosidase inhibitors, and thiazolidenediones are examples of oral

hypoglycemic medicines. Their therapeutic technique focuses on addressing metabolic issues including insulin resistance and pancreatic insulin insufficiency. People with diabetes are more likely to die from heart disease if they don't lose weight, improve their glycemic control and lower their risk of cardiovascular disease (Kumar and Clark 2002).

2.4 Causes of Diabetes Milliteus

When there is an abnormality or disruption in the function of the beta cell gluco-receptors, the beta cells become more sensitive to higher glucose concentrations. Either way, insulin secretion is impeded, and this might lead to ß cell failure in the long run (Alemu *et al.* 2009). Microvascular disease causing cerebral hypoxia and its direct impact on neuronal metabolism and metabolism in hyperglycemia (Wild*et al.* 2009).

Due to a reduction in insulin receptors and 'down regulation' of insulin receptors, peripheral tissues are less sensitive to insulin. People with hypersensitivity and hyperinsulinaemia but normal blood sugar levels also have dyslipidemia, hyperuriaemia, and adipose fat. As a consequence, the liver, muscle, and fat are all insulin resistant. The development of angiopathy has been connected to hyperinsulinemia, according to research (Gupta *et al.* 1978).

Insulin ß cells are weakened due to an excess of the hyperglycemia hormone (glucagon) or fat. Neuronal damage and decreased perineural blood flow were seen in two animal models that had nitric oxide metabolic abnormalities (Alemu *et al.* 2009).

Maturity-onset diabetes (MODY), other endocrine illnesses, pancreatectomy, and gestational diabetes mellitus (GDM) are all examples of type 3 diabetes, which are very rare (Gupta *et al.* 1978).

Diabetes mellitus might have its origins in an imbalanced receptor system. Receptors and enzymes for GLP-1, PPAR, beta3 (ß3) ardent-receptor, dipeptidyl peptidase IV

enzyme, and others are some of the particular ones that have been identified (Gupta *et al.* 1978).

Diabetes neuropathy is now being studied in terms of antioxidant stress, advanced glycocation end products, PKC, and the polyol pathway (Wild *et al.* 2009).

2.5 Treatment

Oral hypoglycemic medicines and insulin. Effort should be made to mimic nature's ability to reduce postprandial hyperglycemia and avoid hypoglycemia between meals with insulin treatment (Ciofeta *et al.* 1999). It doesn't matter whether you administer insulin intravenously or intramuscularly; the location of the injection is just as crucial to the effectiveness and safety of the insulin. insulin formulations include those made from cows, humans, and pigs. Insulin treatment has its downsides and side effects, but it is not without them. Weight gain and hypoglycemia are the most significant adverse effects when insulin doses are wrong and meals and insulin injections are out of sync (Kudlacek *et al.* 1992).

Because of increased truncal fat and muscle growth as a result of insulin treatment for uncontrolled diabetes, weight gain is an inevitable adverse effect. Due to glycosuria, energy losses are reduced (Yki-Jarvinen *et al.* 1999).

Oral hypoglycemic drugs include sulphonyl ureas like glibenclamide and glipizide and biguanides like metformin and phenformin. Insulin production from pancreatic ß cells is promoted by sulfonylureas, which produce hypoglycemia. It is thought that these medicines adhere to and stimulate potassium channels sensitive to ATP to close, resulting in the depolarization of the plasma membrane of ß-cells. Insulin granules may now be synthesized when calcium ions enter voltage-gated channels, thanks to this discovery. Patients with type 2 diabetes who take sulfonylureas may have a rise in insulin levels as a consequence of increased pancreatic insulin synthesis and reduced

hepatic clearance of the hormone. According to early investigations, sulfonylureas cannot have a hypoglycemic effect without a functioning pancreas (Levine 1984).

Not all biguanides are hypoglycemic, however Metformin and other biguanides have antihyperglycemic properties (Bailey *et al.* 1992). When taken in large doses, it does not trigger insulin release from the pancreas or low blood sugar (Clarke *et al.* 1979). A 20-30 percent reduction in hepatic glucose production has been seen when it is administered orally rather than intravenously. Another possible mode of action is impaired gastrointestinal glucose absorption (Perriello *et al.* 1994, Sum *et al.* 1992).

2.6 LDH

LDH catalyzes the conversion of lactate to pyruvate, which is a crucial step in cell energy production. The heart, kidney, liver, and muscles are among the organs with the highest levels of LDH (Arai *et al.* 2007). Note that LDH is mostly located in cells' cytoplasm and only becomes exocytotic after they have died (Sivaramakrishnan *et al.* 2015).

Elevated LDH levels are a defining feature of several illnesses. For example, a heart attack combined with congestive heart failure might result in lung and liver congestion. This pattern can also be caused by advanced cancer and autoimmune illnesses like lupus (Joseph *et al.* 2001). The LDH isoenzymes test may also be used to help distinguish between a heart attack and a myocardial infarction. Within 24–48 hours following a heart attack, LDH levels rise, peak in 2-3 days, and return to normal within 5–10 days.

2.6.1 Role of LDH in diabetes mellites

Patients with diabetes mellitus, either IDDM or NIDDM, are at an increased risk for diseases caused by a variety of variables such as metabolic abnormalities and enzymes such as lactate dehydrogenase (LDH) (Johari *et al.* 2018). Hyperinsulinemic euglycemic clamp study has recently discovered that lactate formation increases as a consequence of

hyperinsulinemia, a scenario comparable to the early stages of T2DM development (Berhane *et al.* 2015). Pre-diabetes, prediabetes, and hyperinsulinemia have all been observed to have higher lactate concentrations in the bloodstream. Patients with poorly controlled T1DM and glycogenic hepatopathy are shown to have raised lactate levels, suggesting that greater plasma lactate concentrations are a common occurrence among diabetics with poor control of their condition (Brouwers *et al.* 2015). Furthermore, lactate has been demonstrated to predict the occurrence of diabetes in the near future (Ohlson *et al.* 1988, Crawford *et al.* 2010).

2.7 Biochemicals in Diabetes Mellites

Changes in a variety of biochemicals may have a role in several of the metabolic dysfunctions that are common in diabetes patients.

2.7.1 Insulin

Pancreatic beta cells generate insulin, a peptide hormone that helps control blood glucose levels. Insulin functions by attaching directly to its receptors on cell plasma membranes. These receptors are found on all cells, although their density varies depending on the cell type, with hepatic cells and adipocytes having the highest density.

Insulin resistance is a syndrome that develops over time and is connected to excess body fat, however genetic causes have been identified. Because there is no widely approved test for insulin resistance, the clinical definition remains ambiguous (Hossan *et al.* 2019). Diabetes and insulin resistance syndromes are clinically recognized as the metabolic consequences of insulin resistance.

Insulin resistance may be diagnosed using the hyperinsulinemia-euglycemic glucose clamp approach. This is a research technique with limited clinical utility, nevertheless, there are a variety of therapeutically effective insulin resistance replacement measures, including as HOMA-IR, HOMA2, QUICKI, triglyceride/HDL ratio, and serum

triglyceride. Furthermore, numerous tests based on serum glucose and/or insulin response to a glucose challenge are used to determine insulin resistance.

2.7.2 Cortisol

T2DM's molecular etiology, which includes insulin resistance and -cell dysfunction, has been linked to cortisol. Two common comorbidities of Cushing's condition are insulin resistance and type 2 diabetes mellitus (T2DM) (Ortiz *et al.* 2019). In the context of subclinical hypercortisolism, it is common to describe the differentiation and proliferation of adipocytes as a means of transferring subcutaneous fat to visceral fat storage. When it comes to visceral fat, glucocorticoid receptors, which are overexpressed in visceral fat, may be responsible for this impact (Anagnostis *et al.* 2009). Cortisol may thus play a key role in the pathophysiology of T2DM due to its development of visceral obesity and direct and indirect interference with insulin signaling.

2.7.3 Magnisium (Mg) and sodium

The body's fourth cation and the most prevalent divalent intracellular cation is magnesium (Mg) (Barbagallo and Dominguez 2015).

Changes in Mg levels are usually associated with T2DM. T2DM patients with poorly regulated blood sugar levels, long-term disease duration, and the advent of micro- and macrovascular chronic complications are more likely to suffer from magnesium insufficiency (Barbagallo *et al.* 2021).

When serum Mg values are less than 0.61 mmol/L, patients are diagnosed as hypomagnesemic (Laecke 2019). Magnesium concentrations less than 0.75 mmol/L are considered pre-clinical hypomagnesemia.

It is possible to have a magnesium shortage without having hypomagnesemia. It is possible for people with normal serum magnesium levels to have a reduction in intracellular and/or ionized plasma magnesium. It is difficult to relate Mg shortage to diseases since most studies have employed total blood Mg concentrations rather than free, ionized, or intracellular amounts of Mg.

DM is a well-known cause of dysnatremia due to a variety of underlying processes (Liamis *et al.* 2014). Glucose has osmotically active properties. Serum osmolality is increased in hyperglycemia due to water loss from cells, which in turn causes sodium concentrations in the blood to be diluted. A correction factor of 2.4 mmol/L is used when blood glucose concentrations are more than 400 mg/dL (22.2-22.2 mg/L) in patients with hyperglycemia, which is determined by multiplying the measured [Na+] by 1.6 for every 100 mg/dL (5.55 mmol/L) rise in serum glucose above normal (Kurniawan *et al.* 2021). Hyperglycemia may dilute Na+, thus it's important to take this into account when measuring Na+ corrected for dilutional effects. The osmotic diuresis that occurs in patients with uncontrolled diabetes may result in hypovolemic hyponatremia. Hypotonic renal losses from osmotic diuresis may lead to hypernatremia if not appropriately compensated for. As a consequence, in individuals with uncontrolled diabetes mellitus, the level of serum sodium (Na+) fluctuates, reflecting a delicate balance between water migration out of cells caused by high blood sugar levels and osmotic diuresis caused by glucosuria.

2.7.4 Uric acid

Uric acid elevation in the blood has been related to the metabolic syndrome and cardiovascular disease morbidity as well as death. Having high amounts of uric acid is a sign of type 2 diabetes. Uric acid levels increase in the early stages of reduced glucose metabolism. Both microvascular and macrovascular complications have been related to high uric acid levels in diabetics (Katsiki *et al.* 2013).

Metabolic syndrome and diabetes are more frequent in those with elevated median levels of urinary alkaline (UA), according to a study of 3,200 Italians aged 25 to 74 years. Researchers discovered that elevated UA was linked to impaired fasting glucose (IFG) (Bombelli *et al.* 2018). When comparing women with normal serum uric acid levels to those with low-normal values, a higher risk of new-onset diabetes was found. When it came to predicting metabolic syndrome, diabetes, and hypertension risk in adult men, serum UA was a strong indicator. Despite this, the link between blood UA and impaired insulin sensitivity in T1DM patients is weaker than in healthy people (Xiong *et al.* 2019).

2.7.5 Lipid profile

Triglycerides, LDL and HDL levels are all affected by diabetes, and these changes are more pronounced in those with the disease. LDL and HDL cholesterol levels are comparable in T1DM individuals who have successfully managed their blood sugar levels (Anagnostis *et al.* 2009). T2DM patients, on the other hand, have aberrant lipid profiles even when they have effective glycemic control. Dylipidemia is estimated to affect 45 percent of T2DM patients.

Total cholesterol is an important component of all human cell membranes, since it helps to construct and maintain membranes as well as regulate membrane fluidity during a range of physiological activities. Diabetic individuals have the same total cholesterol and HDL cholesterol values as the general population. Those with diabetes, on the other hand, have higher levels of LDL cholesterol and triglycerides.

Triglycerides (TGs): In human adipose tissue, TGs are the most abundant lipid. The risk of T2DM was linearly proportional to TG levels (Zhao *et al.* 2019). Furthermore, TGs were found to be the most significant lipid among various lipids linked to T2DM in a study (Sung and Reaven 2015). Various studies have found a link between TG levels and T2DM in children and adolescents (Tirosh *et al.* 2008). Other cross-sectional investigations, on the other hand, have found a link between TGs and T2DM (Ozder 2014, Thambiah *et al.* 2016). However, several additional investigations have proven

that high TGs concentrations can predict the occurrence of T2DM on their own (Zhao *et al.* 2019).

HDL, like other lipoproteins, undergoes significant structural and functional changes as a result of diabetes (Farbstein and Levy 2012). However, because dyslipidemia can develop years before diabetes, it's difficult to say which of these changes are linked to the disease's pathognomonic traits and which predate and accelerate its course. The significance of cholesterol metabolism and HDL function in T2DM pathogenesis has recently received a lot of attention.

Several variables contribute to the HDL dysfunction seen in T2DM, according to new research. It was discovered that oxidation and glycation of HDL-associated proteins rendered them inactive. Metabolic disorders connected to DM reduce the effectiveness of reverse cholesterol transfer through altering gene expression and activity of HDL-metabolizing enzymes.

With type 2 diabetes (T2DM), despite normal LDL cholesterol levels, the LDL metabolism is substantially affected. Non-diabetic normolipidemic controls have LDL cholesterol levels equivalent to those of diabetics (Singh *et al.* 2020). A prolonged LDL plasma residence time is seen in T2DM patients, despite the presence of normal LDL levels in the circulation. Longer LDL plasma residence time is thought to enhance cholesterol buildup in arteries' inner linings. Atherosclerotic lesions and lipid buildup in artery walls have been linked to increased LDL plasma residence duration in animal research.

3. MATERIALS AND METHODS

This study's instrumentation, as shown in Table 3.1.

Table 3.1 Instruments utilized in this investigation are listed below

Instruments and glasses	Company	Country
ELISA	Labon	China
Spectrophotometer	Biobase	India
Centrifuge	Memmert	Germany
Light microscope	Olympus	Japan
Oven	Memmert	Germany
Water bath	Memmert	Germany
Shaking water bath	Memmert	Germany
Sysmex device	Sysmax	Japan
Pipette	BioSan	Germany
Different glasses	-----	China
Refrigerator	BEKO	Turkey

3.1 Subjects

Non-diabetic participants were also included in this research, which comprised 100 diabetics (males and females) and 40 non-diabetics (control). All of the participants are adults between the ages of 25 and 55. The research was conducted in various hospitals in Kirkuk between October 2021 and January 2022.

3.2 Blood Samplings

Samples were collected from research participants after a fast of 10-12 hours (patients and healthy people). Before centrifugation, blood samples were kept in Gold-top SST and EDTA tubes. The specimens were centrifuged for 10 minutes at 3500 rpm to separate the serum samples, which were then kept in Eppendorf tubes. After the sample collection procedures were completed, all samples were dissolved to prepare them for biochemical analysis.

3.3 Biochmemical Tests

3.3.1 Total cholesterol

Allain described the enzymatic approach for measuring cholesterol in the blood (Tietz 1999) and used (BioLabo kit/ France/ spectrophotometer):

The total cholesterol concentration was calculated according to the Equation 3.1.

$$\text{Conc. of cholesterol} = \frac{\text{Abs (Test)}}{\text{Abs (Standard)}} \times Concentration\ of\ Standard\ \frac{200mg}{dL} \quad (3.1)$$

3.3.2 Triglyceride

The enzymatic method for measuring triglyceride in the blood was described by Allain as follows (Tietz 1999) and using (BioLabo kit/ France/ spectrophotometer):

The triglyceride concentration was calculated according to the Equation 3.2.

$$\text{Triglyceride} = \frac{\text{Abs (test)}}{\text{Abs (Blank)}} \times Standard\ (200\ mg/dL) \quad (3.2)$$

3.3.3 High density lipid (HDL)

The enzymatic method for measuring triglyceride in the blood was described by Allain as follows (Tietz 1999) and using (BioLabo kit/ France/ spectrophotometer):

HDL concentration was calculated according to the Equation 3.3.

$$\text{HDL} = \frac{\text{Abs (test)}}{\text{Abs (Blank)}} \times Standard\ (200\ mg/dL) \quad (3.3)$$

3.3.4 Low density lipid (LDL)

LDL concentration was calculated according to the Equation 3.4.

$$LDL = Total\ cholesterol - HDL - VLDL \quad (3.4)$$

3.3.5 Very low density lipid (VLDL)

VLDL concentration was calculated according to the Equation 3.5.

$$VLDL = triglyceride/5 \quad (3.5)$$

3.4 Uric Acid

Allantoin, carbon dioxide, and hydrogen peroxide are created when uricase interacts with uric acid. Amino-antipyrine and Dichlorohydroxybenzene Sulfonate form quinoneimine when hydrogen peroxide reacts with chromogens in the presence of peroxidase. An increase in the absorbance at 505 nm indicates an increase in uric acid concentration in a sample (495-505).

Procedure: The working reagent, samples, and standard were all incubated at reaction temperature (37°C). Following that, the additions were made in line with the Table 3.2.

Table 3.2 Steps of uric acid procedure

Sample	25 μL
Reagent R	1000 μL
Mix. Allow 5 minutes at 25°C to stand. Using a reagent blank, measure absorbance at 505 (495-505) nm. For 30 minutes, the color remains steady.	

Calculation: The concentration of uric acid is calculated according to the Equation 3.6:

$$\frac{Sample}{standard} \times standard \quad (3.6)$$

3.5 Lactate Dehydrogenase (LDH)

In a variety of biological samples, the LDH Activity Assay kit may be used to assess LDH activity. The exam is straightforward, fast, and accurate. This kit uses a colorimetric (450 nm) test to identify LDH's role in lowering NAD to NADH.

Procedure: Prepare the Master Reaction Mix according to Table 3.3's instructions. Each reaction requires 50 liters of the Master Reaction Mix (well).

Table 3.3 steps of LDH procedure

Rragent	Master reaction mix
LDH assay buffer	48 µL
LDH substrate mix	2 µL

- Pour 50 liters of Master Reaction Mix into each well. Using a horizontal shaker or pipette, thoroughly mix the components into a smooth paste. Keep the dish out of direct sunlight while it is incubating.
- 2–3 minutes into the procedure, take the first readings (Tinitial). Measure the absorbance at 450 nm for the first time (A450). The starting point (A450) must be within the standard curve's linear range at all times.
- For five minutes, incubate the plate at 37°C and record the results (A450). Keep the dish out of direct sunlight while it is incubating.
- To get an accurate reading, keep taking measurements until the most active sample (12.5 nmole/well) surpasses the highest criterion. The most active sample has reached or exceeded the linear range of the standard curve at this point.
- Before the most active sample reaches or surpasses the linear range of the standard curve, take a penultimate reading [(A450)final] to determine enzyme activity. The penultimate reading takes place at this point. The standard curve's linear range is important to the final measurement.

Calculations: Use Equation 3.7. to subtract the final measurement [(A450)final] for the 0 (blank) NADH standard from all other final measurements [(A450)final].

$$\Delta A450 = (A450)\text{final} - (A450)\text{initial} \quad (3.7)$$

The quantity of NADH created by the assay between Tinitial and Tfinal may be calculated by comparing the A450 of each sample to the standard curve (B).

3.6 Insulin

Insulin measured by DRG insulin enzyme immunoassay kit (ELISA) based on the sandwich principle.

3.7 Electrolytes

3.7.1 Sodium

Precipitation as the triple salt sodium uranyl zinc acetate was the most popular technique of measuring sodium in human fluids before flame photometry and ion-selective electrodes. In 1927, Kolthoff developed this method, and the precipitate has subsequently been employed in a wide range of applications. For the solubilized residue, Albanese and Lein (1948) employed colorimetry; for the color fading of the yellow supernatant, Bradbury utilized colorimetry. As with the prior approach, this one uses a protein-free supernate in which sodium precipitates as the triple salt. As the sodium content in the material increases, the absorbance of the supernate-color reagent combination decreases.

Test procedure: Pipet the following volumes (mL) into labelled tubes, mixing immediately after each addition of the color reagent Table 3.4.

Table 3.4 Sodium procedure steps

Tubes	Blank	Sample	Standard
R1 Reagent	2.5 mL	2.5 mL	2.5 mL
Standard	-	-	0.5 mL
Distilled water	0.5 mL	-	-
Sample	-	0.5 mL	-
Incubate tubes at room temperature for 10 minutes (15-30 ºC). Within 30 minutes, read and record the absorbance of the reagent blank, standard and sample.			

Calculations: Sodium concentration was calculated from the absorbance depending on the Equation 3.8 below:

$$\text{Results} = \frac{\text{Abs (sample)} - \text{Abs (standard)}}{\text{Abs (standard) x C Standard}} \times mg/dL\ total\ Sodium\ A\ Standard \quad (3.8)$$

3.7.2 Magnesium

It is based on the binding of calmagite to magnesium at an alkaline pH, which results in a wavelength shift of the complex's absorption. cromophore intensity is proportional to the sample's magnesium concentration.

Test procedure: Pipet the following volumes (mL) into labelled tubes, mixing immediately after each addition of the color reagent.

Table 3.5 Magnesium procedure steps

Tubes	Blank	Sample	Standard
R1 Reagent	1 mL	1 mL	1 mL
Sample	-	10 µL	-
Standard	-	-	10 µL
Sample and standard absorbance (A) at 520 nm are measured against the blank reagent.			

Calculations: Magnesium concentration was calculated from the absorbance depending on the Equation 3.9 below:

$$\text{Results} = \frac{\text{Abs (sample)}}{\text{Abs (standard) x C Standard}} = \text{Magnesium A Standard} \quad (3.9)$$

3.8 Statistical Analysis

For statistical analysis, SPSS version 21 and GraphPad prism version 8 were utilized. MeanSE was used to represent the results of statistical tests and bar graphs. Comparisons were made between the patient and control groups based on their respective parameter means using an unpaired T-test.

4. RESULTS AND DISCUSSION

4.1 Age and BMI

Table 4.1 showed significant (P<0.05) difference in age of subjects. Whereas, the average age of control group is 31.23 ±1.27, while the average age of diabetes type I group is 41.62 ±1.79. The average age of diabetes type II group is 36.15 ±2.09. BMI in control group is 23.99 ±1.76 and in diabetes (type I and II) group is 28.72 ±1.12 and 27.05 ±0.87 respectively.

Table 4.1 Comparison between difference groups in Age and BMI

Group	Mean ± SE	
	Age (year)	BMI (kg/m^2)
Control	31.23 ±1.27 b	23.99 ±1.76 b
Diabetes Type I	41.62 ±1.79 a	28.72 ±1.12 a
Diabetes Type II	36.15 ±2.09 a	27.05 ±0.87 ab
LSD value	5.524 **	3.822 *
P-value	0.0011	0.0418
In other words, various letters in the same column might mean quite different things to different people. P0.05, P0.01, respectively).		

4.2 Lipid profile

It is clear from Table 4.2 that there is a statistically significant difference between the two groups tested (P0.05). There is a substantial (P 0.05) rise in total cholesterol levels in individuals with type I and type II diabetes compared to the control group (154.01–15.09). Figure 4.1 shows an example of this. Patients with diabetes type I (180.38.63) and type II (274.115.9) had significantly higher triglyceride levels (P 0.05) than those in the control group (143.25 6.86). As shown in the following Figure 4.2: Patient's with type I (36.06 1.73; 145.6 10.89) and II (54.81 3.18; 161.62 +4.65) diabetes had significantly higher levels of VLDL and LDL than those in the control group (which were both 30.65 1.37 and 104.94" Figures 4.3, Figure 4.4 and Figure 4.5, respectively. Patients with diabetes types I and II had non-significant (P 0.05) changes in levels when compared to the control group.

Table 4.2 Comparison of lipid profiles between several ethnic groups

Group	Mean ± SE (mg/dl)				
	Cholesterol	Triglyceride	VLDL	HDL	LDL
Control	154.01±15.09 b	143.25 ±6.86 c	30.65 ±1.37 c	33.45 ±2.62	104.94±13.51 b
Diabetes Type I	193.25±17.24 a	180.3±8.63 b	36.06 ±1.73 b	28.43 ±1.39	145.6±10.89 a
Diabetes Type II	201.0±12.03 a	274.1±15.9 a	54.81 ±3.18 a	27.15 ±2.9	161.62 ±4.65 a
P-value	0.0053	0.003	0.003	0.1586	0.025
Means having with the different letters in same column differed significantly. * (P≤0.05), NS: Non-Significant.					

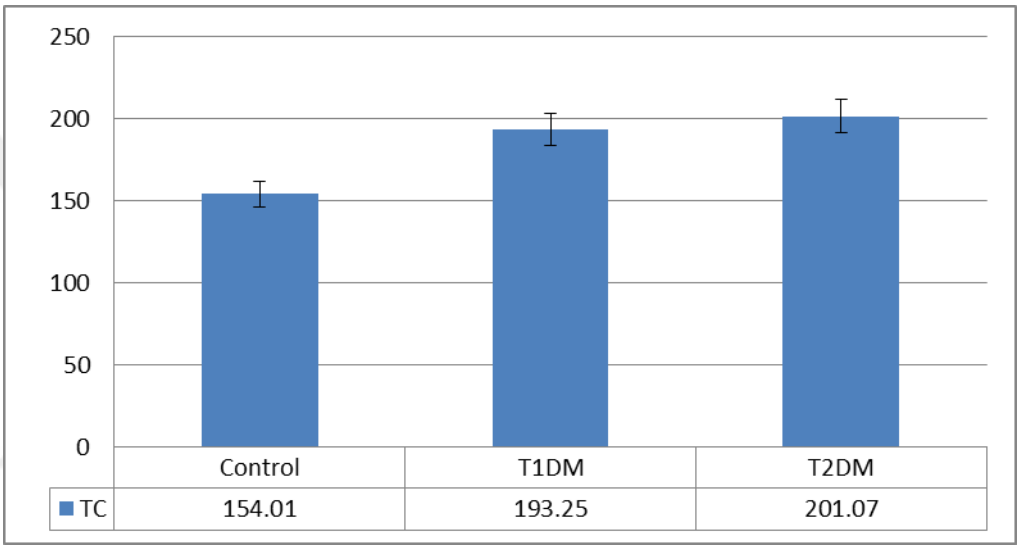

Figure 4.1 TC levels in all groups

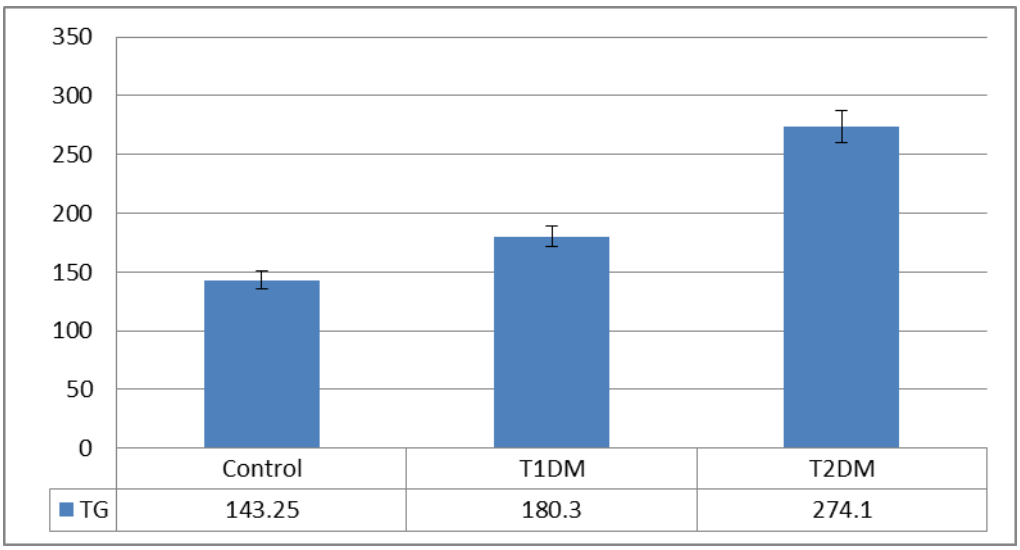

Figure 4.2 TG levels in both groups

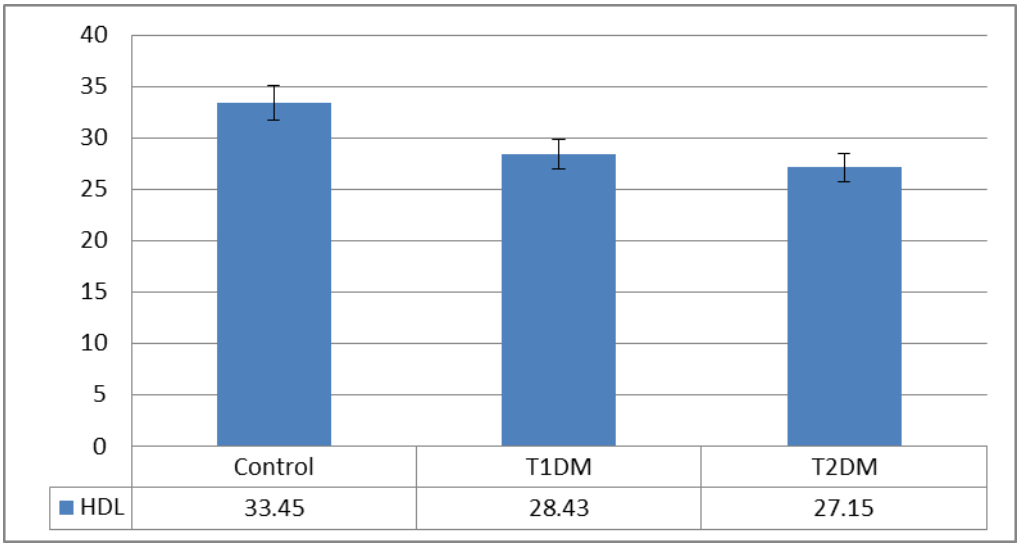

Figure 4.3 HDL levels in both groups

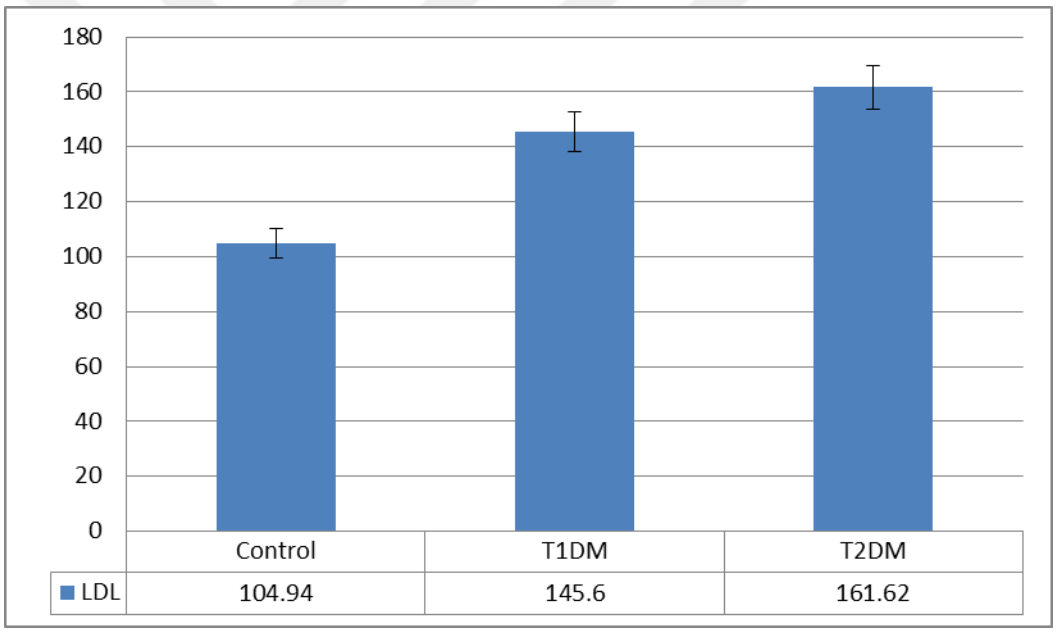

Figure 4.4 LDL levels in all studied groups

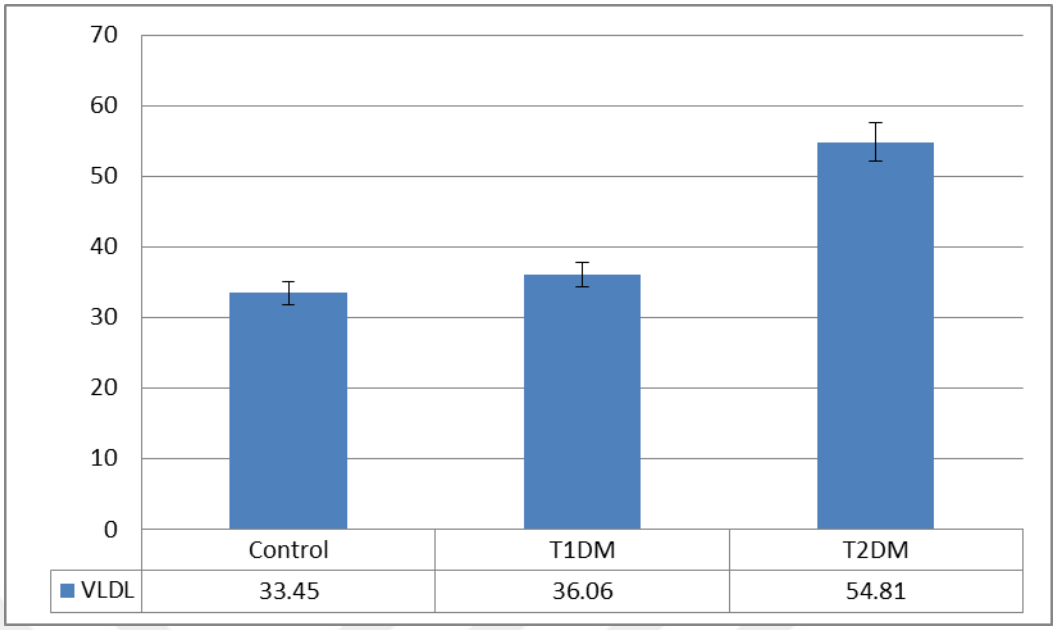

Figure 4.5 VLDL levels in all studied groups

The participants in this study were drawn from a random sample population that was chosen based on strict criteria that included non-diabetics and volunteers as controls. The results that relate diabetes mellitus to changes in the lipid profile of the blood are in line with (Ononogbu 1988, Sccopola *et al.* 1995).

Because the glucose and lipid metabolisms are interwoven, several variables may influence the blood lipid levels of diabetes patients. Results showed that diabetic individuals had a considerably higher lipid profile and high cholesterol levels in type 2 diabetics (male and female) as well as hypertensive type 2 diabetics (male and female). In order to diminish the body's cholesterol pool, HDL-C increases the clearance of cholesterol from peripheral tissues by boosting HDL-C levels. Type 2 diabetes and low HDL-C blood levels are often linked (Karee and Banaa 1991).

People with T2DM have dangerously high levels of LDL in their bloodstream, which is linked to an increased risk of cardiovascular disease (Veiraiah 2005). This study found a significant rise in cholesterol in T2DM patients, which is in agreement with a study that found that T2DM is linked to a significant rise in total cholesterol levels in people with the disease (Haffner *et al.* 1998).

People with diabetes have greater triglycerides, lower HDL cholesterol, and more tiny, dense LDL particles than those without diabetes, according to another study (Sniderman *et al.* 2001). They also have a two to four times higher risk of cardiovascular events than adults without diabetes (Laakso 2001, Fox 2010).

The large rise in cholesterol in table 1 and table 2 between control and T2D is due to the body's utilization of adipose tissue as a source of energy rather than sugar, which causes an increase in cholesterol and fatty acids in the blood (hyperlipidemia). On the other hand, it could be attributed to diabetes-related inflammation. Inflammation and elevated LDL cholesterol cause cholesterol elevation in T2D patients (Dhindsa 2007).

4.3 Uric acid, LDH and insulin

Uric acid levels showed a significant ($P < 0.05$) increase in patients of diabetes type I (6.79 ±0.57) and type II (7.61 ±0.31) compared with control group (3.57 ±0.13) Figure 4.6. LDH shows a significant ($P < 0.05$) increase in patients of diabetes type I (180.3±8.63) and type II (274.1±15.9) compared with control group (143.25 ±6.86) Figure 4.7. Insulin levels showed a significant ($P < 0.05$) decrease in patients of diabetes type I (3.6 ±0.25) and type II (3.64 ±0.12) compared with control group (5.13 ±0.29) Figure 4.8 as shown in Table 4.3.

Table 4.3 Comparison between difference groups in uric acid, LDH and insulin

Group	Mean ± SE		
	Uric acid (mg/dl)	LDH (mg/dl)	Insuline(µl U/m)
Control	3.57 ±0.13 b	437.2 ±50.51 c	5.13 ±0.29 a
Diabetes Type I	6.79 ±0.57 a	609.91 ±27.8 b	3.6 ±0.25 b
Diabetes Type II	7.61 ±0.31 a	724.41 ±49.22 a	3.64 ±0.12 b
P-value	0.0035	0.016	0.012
In other words, various letters in the same column might mean quite different things to different people. P0.05, P0.01, respectively).			

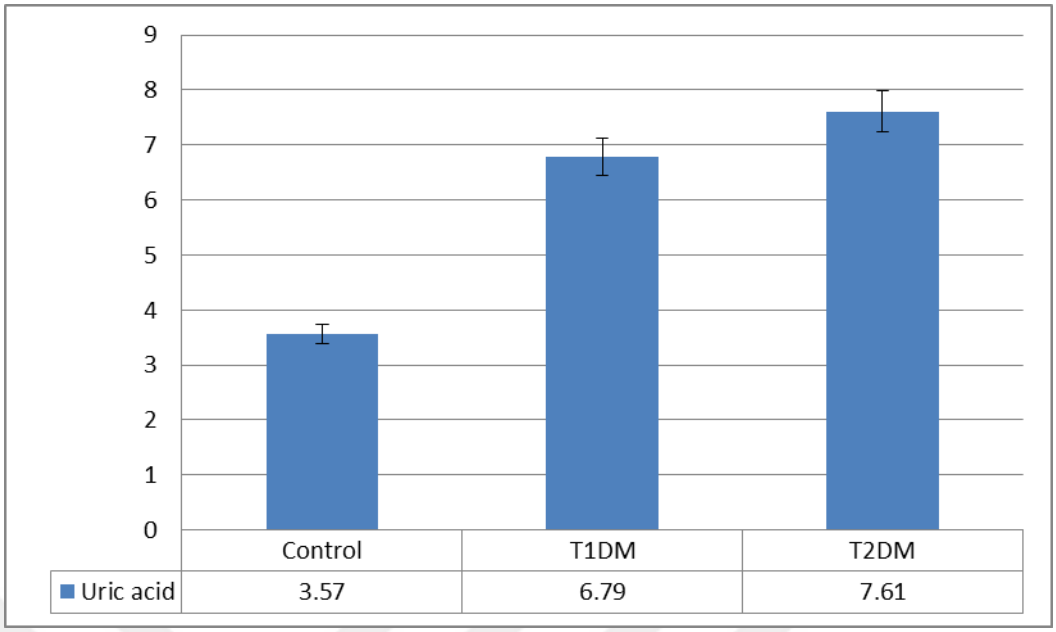

Figure 4.6 Uric acid levels in all studied groups

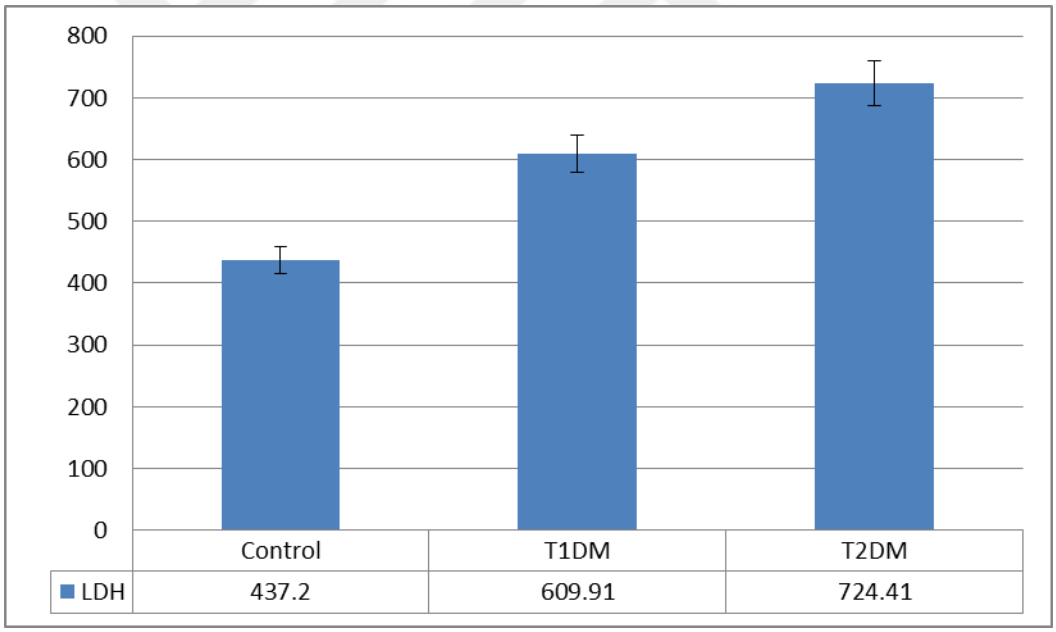

Figure 4.7 LDH levels in all studied groups

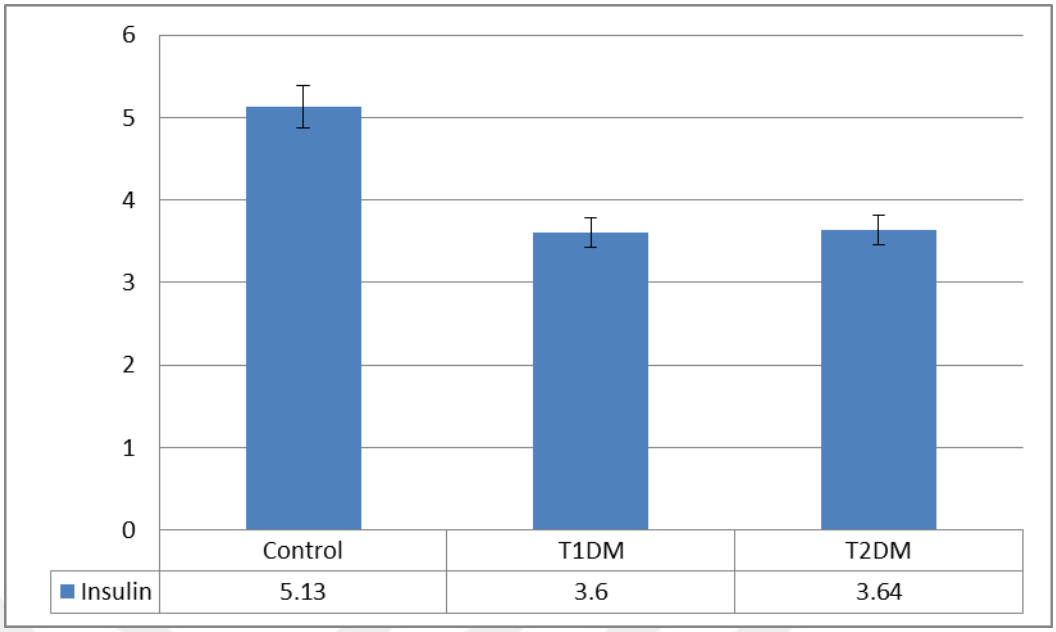

Figure 4.8 Insulin levels in all studied groups

Patients with type II diabetes had substantially greater blood uric acid than controls (p0.0001), and uric acid levels in type II diabetes were higher than in type I diabetes, according to this research. Hyperuricemia has been associated to obesity, insulin resistance, and type II diabetes in previous studies. These new data back up that theory (Koenig and Meisinger 2008). Diabetic patients have lower serum uric acid than controls, according to (Nan *et al.* 2007*).*

In addition, type 2 diabetics had significantly greater fasting blood uric acid concentrations than control participants in this investigation. Urine uric acid clearance is lower in normal volunteers with insulin resistance, according to research, (Facchini *et al.* 1991) explain the source of excessive uric acid in enhanced insulin resistance. They theorized that compensatory hyperinsulinemia in insulin-resistant people causes decreased uric acid excretion in the kidneys, as well as increased sodium reabsorption. On the other hand, endothelial nitric oxide bioavailability, which is essential for insulin-stimulated glucose uptake in skeletal muscle, has been shown to be impaired by uric acid (Khosla *et al.* 2005, Roy *et al.* 1998).

Many studies have questioned the role of uric acid in vascular disease. Uric acid is one of the body's most important endogenous water-soluble antioxidants, according to some studies (Becker 1993), and diabetes and its vascular implications are connected to increased oxidative stress (Baynes 1991). A high uric acid level may signal that the body is seeking to protect itself from free radical damage by increasing the products of endogenous antioxidants, such as uric acid. Aside from protecting the endothelial enzymes from oxidative damage, uric acid is also able to maintain the endothelium's capacity to regulate venous dilation in the face of oxidative stress (Becker 1993).

According to another line of study, because human atherosclerotic plaque contains more uric acid than the arteries of control participants, this uric acid may directly contribute to the development of atherosclerosis (Suarna *et al.* 2005). It is possible that lipoproteins that bind to uric acid crystals may decrease inflammatory responses since inflammation is a feature of atherosclerosis (Fuster *et al.* 1992, Feingold *et al.* 1992).

Furthermore, the results of this investigation demonstrated a significant increase in LDH activities. These findings are in line with certain earlier findings (Yousaf and Powell 2012, Nsonwu-Anyanwu *et al.* 2015). Few explanations may explain elevates in cardiac enzymes activity such as LDH in general. It's possible that cells release LDH into the bloodstream as a result of tissue injury or RBC death. Diabetes mellitus pathogenesis and chemical toxicity may lead to elevated LDH activity in organs such as the heart, liver, and muscle, which are especially vulnerable (Chikezie *et al.* 2015).

Tissue damage and necrosis may be detected by looking for elevated levels of LDH activity. a low blood LDH activity suggests that tissue damage has not occurred, while a high serum LDH activity implies necrosis of the tissue (Chikezie *et al.* 2018). HF, which largely manifests clinically as dehydration and metabolic acidosis, also raises LDH levels. Myocardial damage in DKA patients varies in severity, and cardiac muscle enzymes like creatine phosphokinase and LDH are significant indicators of cardiac injury. Water loss and acidity are the hallmarks of diabetic ketoacidosis (DKA), a serious consequence of diabetes induced by insulin deficiency (Zhao *et al.* 2018).

When a patient's diabetes progresses to a severe level, DKA develops. Insulin activity is diminished, ketone bodies are raised, and the excretion of ketones is boosted at this point in time. Due to the depletion of oxygen and high water loss, the body has a decreased capacity to fight infection when this occurs. As a result, patients frequently experience an increase in serum potassium or a decrease in serum sodium (Jefferies *et al.* 2015).

When DKA occurs, the elevated sugar level's osmotic pressure might cause hypoxic ischemic injury. According to the findings of this investigation, LDH activities in diabetics are much higher than in healthy persons. DKA produces a loss of oxygen and hypoxia ischemia injury to cardiac tissues because it causes body to become dehydrated. Simultaneously, the hypertonic state of high glucose levels increases permeability of cell membrane, and the cell's metabolism becomes disordered, resulting in mitochondrial necrosis and cell apoptosis. The secretion of intracellular cardiac enzyme indicators, such as LDH, is increased as a result of this (Zhao *et al.* 2018).

Furthermore, chronic hyperinsulinemia has been linked to endothelial dysfunction, atherosclerosis, and the development of heart disease. Poor metabolic regulation accelerates these dysfunctions. There may be a correlation between elevated LDH activity in diabetics with poor glycemic control and diabetes-related cardiac dysfunction. The action of insulin on the liver and muscular tissues may also contribute to the increased enzyme activity seen in diabetes. Serum liver enzyme levels may contribute to higher LDH activity in diabetes because of diabetes' link to muscle and liver damage (Nsonwu-Anyanwu *et al.* 2015).

Serum insulin levels are low in both types of diabetes. Absolute insulin deficiency is more likely in type 1 diabetes than in type 2 diabetes because of the pancreas' loss of insulin-producing beta cells. (Nicki *et al.* 2010).

4.4 Trace Elements

Serum sodium levels showed a significant (P <0.05) decrease in patients of diabetes type I (134.41±1.25) and type II (134.97±2.2) compared with control group (140.14±1.67) Figure 4.9. Magnesium shows a significant (P <0.05) decrease in patients of diabetes type I (1.28 ±1.07) and type II (1.35 ±0.06) compared with control group (2.43 ±0.13) Figure 4.10 as shown in Table 4.4.

Table 4.4 Comparison between difference groups in Na and Mg

Group	Mean ± SE	
	S. Na (mmol/L)	S. Mg (mg/dl)
Control	140.14±1.67 a	2.43 ±0.13 a
Diabetes Type I	134.41±1.25 b	1.28 ±1.07 b
Diabetes Type II	134.97±2.2 b	1.35 ±0.06 b
P-value	0.0487	0.0017
In other words, various letters in the same column might mean quite different things to different people. * (P 0.05), NS: Non-Insignificant.		

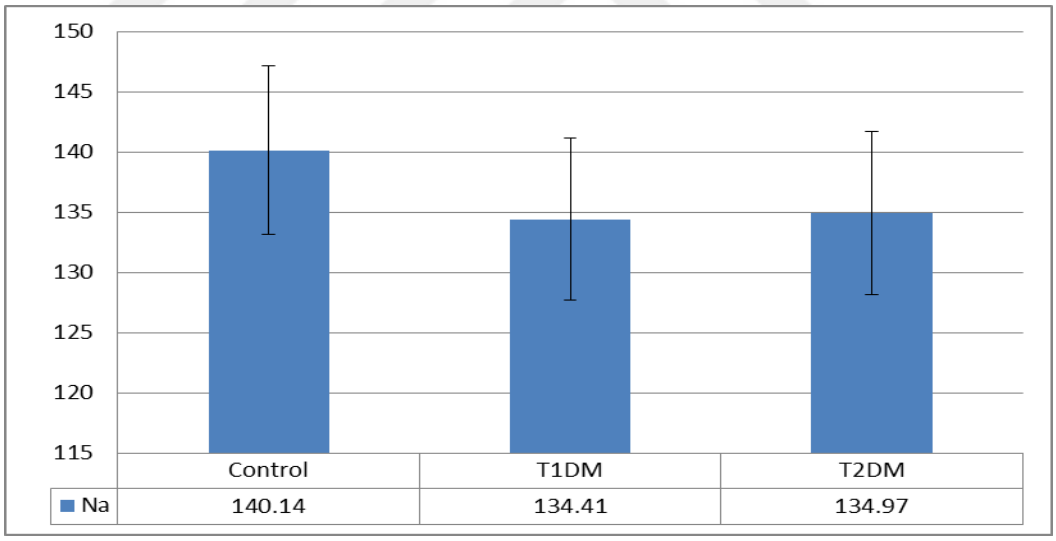

Figure 4.9 Na levels in all studied groups

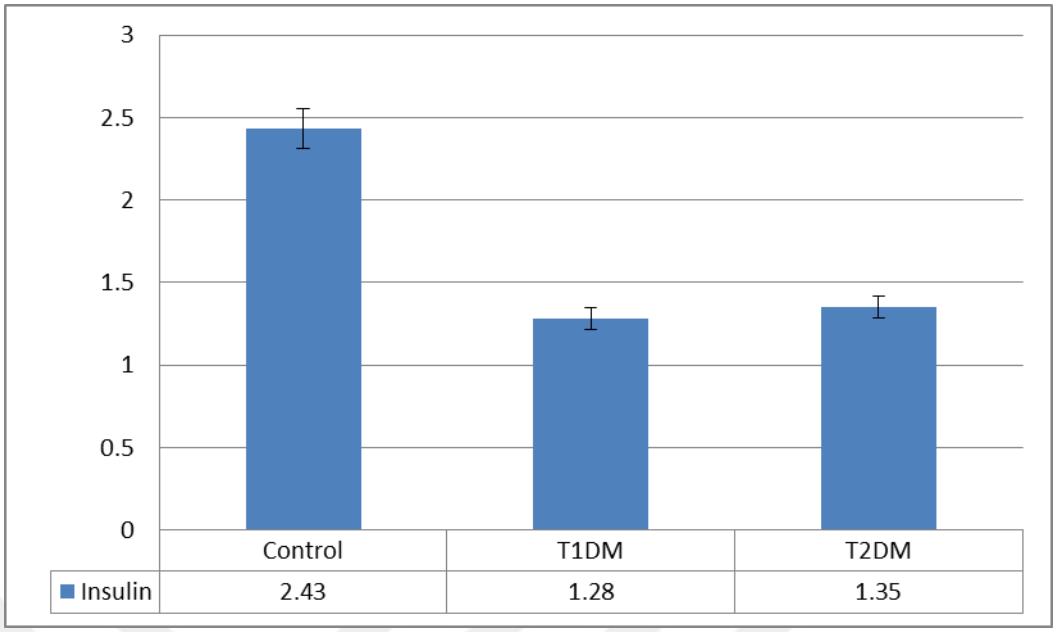

Figure 4.10 Mg levels in all studied groups

Dehydration-induced electrolyte loss or diabetic kidney failure might be to blame for the drop in blood Na+ levels seen in diabetic subjects (Rao 1992). Hyperglycemia causes the kidneys to constantly expel water via the renal tubules in an effort to remove the excess glucose from the body. Na+ is also lost as a result of this water loss. Tissue dehydration might lead to mortality if the body's salt stores are drained at an alarming rate (Leonard and John 1989). Serum Na+ and Ca2+ levels decreased significantly in persons with diabetes mellitus. Earlier studies have confirmed these conclusions (Levy *et al.* 1986, Nair *et al.* 1982, Haglin and Tornkvist 2011).

The results of the current investigation revealed that diabetic patients in Kirkuk had lower serum magnesium levels than healthy control persons. Different researchers in other nations have come to similar conclusions. Hypomagnesemia has been observed to occur more frequently in patients with type 2 diabetes in the United States than in their non-diabetic counterparts, according to (Pham *et al.* 2014). Low total serum magnesium levels are common in type 2 diabetic Omani patients, according to (Al-Osali *et al.* 2009). According to (Seyoum *et al.* 2008), Ethiopians with diabetes mellitus have decreased magnesium levels, putting them at a higher risk of magnesium-related problems. Low magnesium levels have also been documented in type 2 diabetes patients

in various countries, including Italy (Corica *et al.* 2006), India (Lal *et al.* 2003), and Bangladesh (Khan *et al.* 1999). The causes of the high prevalence of magnesium insufficiency in diabetics are unknown, however they could include higher urine loss, reduced dietary intake, or poorer magnesium absorption when compared to healthy people (Waltia *et al.* 2003). Several studies have shown that consuming magnesium can help diabetic patients improve their magnesium levels.

5. CONCLUSIONS AND RECOMMENDATION

5.1 Conclusions

- Both kinds of diabetes had elevated levels of total cholesterol, triglycerides, LDL, and VLDL, according to the results of this research (P0.05).
- HDL levels declined significantly (P 0.05) in both forms of diabetes in the present research.
- In the present investigation, uric acid concentrations in both kinds of diabetes were shown to be significantly (P0.05) elevated.
- Both kinds of diabetes had substantial (P0.05) increases in LDH, according to the results of this investigation.
- Insulin concentrations fell significantly (P0.05) in both kinds of diabetes, according to the results of this research.
- Both kinds of diabetes had significantly lower salt concentrations, according to the results of this research (P0.05).
- Magnesium concentrations in both kinds of diabetes were significantly (P 0.05) lower in the present research.

5.2 Recommendation

- Determining the concentration of other types of trace elements in serum of diabetes patients.
- Determining the concentration of other types of hormones in serum of diabetes patients.
- Determining the concentration of some interleukins in serum of diabetes patients.
- Determining the concentration of Cluster of Differentiation (CD Markers) in serum of diabetes patients.

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