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# A CORRELATION STUDY OF DIABETES MELLITUS WITH SOME OF ITS CONSEQUENCES INCLUDING RETINOPATHY

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**Abstract**

**Background**

It is difficult for individuals with diabetes mellitus to manage all of their symptoms at once because the disease is often linked with hypertension and hyperlipidaemia. The quality of life for diabetic patients is further diminished by other comorbidities, such as nephropathy, anaemia, and cardiovascular disorders. A frequent way to measure glycaemic management is by looking at the haemoglobin A1c, which shows the average blood glucose levels over a few months. In order to improve illness management, it is critical to understand how comorbid diseases affect HbA1c and related metrics.

**Materials and Methods** There were a total of 104 people who participated in the research; half of them had diabetes mellitus (DM), while the other half served as a control group. There were various demographic and anthropometric factors measured, including age, gender, weight, and the presence or absence of anaemia, nephropathy, hypertension, hyperlipidaemia, HbA1c levels, and cardiac problems.

**Results** Researchers found that HbA1c levels were much higher in the diabetes group compared to the control group. Furthermore, hypertension and hyperlipidaemia were more common in the DM group. It was also discovered that HbA1c readings are impacted by demographic variables such as gender, age, and weight.

**Conclusion** Patients with diabetes are more likely to have hypertension and hyperlipidaemia, and their HbA1c levels are much greater than those of non-diabetic controls. Glycaemic regulation is influenced by several factors, including gender, age, and weight. Improving patient care may be possible in the future thanks to algorithms developed using machine learning techniques that can detect these changes early.

**Keywords** Hypertension, nephropathy, haemoglobin A1c, diabetes mellitus, cardiovascular disease, machine learning.

## Introduction

Diabetes mellitus, a metabolic illness that strikes at varying rates in nearly every population on Earth, is a major issue in public health around the world. This condition is characterised by elevated blood sugar levels, or hyperglycaemia, due to insulin resistance or inadequate hormone secretion.



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The rising prevalence of diabetes presents major challenges to healthcare systems, necessitating comprehensive strategies for prevention and management. Effective intervention requires a multifaceted approach, encompassing education, lifestyle changes, and access to medical care. Moreover, public awareness campaigns play a crucial role in informing individuals about risk factors and encouraging early detection. Such initiatives not only empower individuals to take charge of their health but also contribute to reducing the long-term economic burden associated with diabetes. Collaborative efforts between governments, healthcare providers, and communities are essential to create sustainable solutions that address this growing epidemic. By fostering a supportive environment and promoting healthy habits, communities can significantly reduce the impact of this pervasive disease. By addressing these factors, we can significantly reduce the burden of this chronic disease and improve the quality of life for those affected. Efforts must focus on promoting healthier lifestyles, improving access to medical care, and enhancing public awareness to effectively combat this global epidemic. Because poor control is associated with the development of complications, glycaemic control is critical for the efficient management of diabetes. [1] and [2]. Tragically, complications arising from diabetes cause the loss of more than 5 million lives annually. Efforts to improve awareness and access to treatment are essential in combating this global crisis. In addition to increasing awareness, promoting healthier lifestyle choices through diet and exercise can significantly reduce the risk of developing diabetes. Moreover, community-based initiatives that encourage regular health screenings and education about the disease can empower individuals to take charge of their health. By fostering a collective commitment to prevention and management, society can work towards reducing the burden of diabetes on individuals and healthcare systems alike. Governments, healthcare providers, and communities must collaborate to implement effective strategies and provide individuals with the necessary support. By fostering early diagnosis and promoting healthier lifestyles, we can significantly reduce the burden of diabetes-related complications and enhance the quality of life for millions. The prediction indicates that the number of adults with diabetes will rise from 422 million to 642 million by 2040. Both fasting blood glucose levels and glycosylated haemoglobin A1c (HbA1c) play crucial roles in the diagnosis and management of diabetes. Diabetes is a major cause of death and disability, even if it does not cause the disease itself. Instead, they are linked to complications that develop as a result of uncontrolled diabetes. In this category you can identify disorders affecting the nervous system and the big and tiny blood vessels, such as microvascular diseases affecting the retina and kidneys and macrovascular diseases affecting the heart and blood vessels, such as peripheral arterial disease and coronary heart disease. [1, 2], and 3]. There are several ways diabetes mellitus can be categorised: Type 1 and Type 2 diabetes represent the most common classifications, based on the underlying mechanisms of the disease. Additionally, gestational diabetes is a temporary condition that can occur during pregnancy, highlighting the diverse nature of diabetes management and treatment approaches. Effective management of diabetes is crucial to minimising complications and improving the quality of life. The therapy often involves a comprehensive approach that includes lifestyle modifications, regular monitoring of blood glucose levels, and appropriate pharmacological interventions tailored to the individual's specific needs. Furthermore, education and support for patients play a vital role in fostering adherence to these management strategies. By empowering individuals with knowledge about their condition, they are better equipped to make informed



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decisions and maintain a healthy lifestyle. T1DM is characterised by an utter lack of insulin and occurs when pancreatic β-cells are destroyed as a result of an autoimmune attack by the immune system. Diagnosis typically occurs in younger patients, and insulin treatment is necessary for the rest of their lives [4].

• Diabetes Mellitus Type 2 (T2DM): Hyperglycemia caused by insulin secretion or insulin action abnormalities or both characterises the metabolic illnesses known as type 2 diabetes mellitus (T2DM) [4].

4.The early development of symptoms and the presence of β-cell abnormalities that restrict insulin secretion are hallmarks of MODY diabetes, a type of monogenetic diabetes that is transmitted by autosomal dominant inheritance. About five per cent of people with diabetes have MODY diabetes [4].

### 1.1 Clinical Manifestations

The intensity of diabetic symptoms is determined by the blood sugar level. Type 2 diabetes, gestational diabetes, or prediabetes might cause some patients to not show any symptoms at all [4, 6, 12, 13, 14]. Type 1 diabetes is characterised by a faster onset and more severe symptoms. The following are some of the symptoms of both type 1 and type 2 diabetes:

o There is a noticeable increase in thirst. o Frequent urination often accompanies this heightened thirst, as the body attempts to eliminate excess glucose through urine. Additionally, patients may experience fatigue, blurred vision, and slow-healing wounds, which are all indicative of fluctuating blood sugar levels.

o Peeing a lot.

o Becoming a healthier weight naturally.

o The urine contains ketones.

o Experiencing fatigue and weakness. 6.

The individual is experiencing a fluctuating state of mind. This mental instability can lead to irritability and difficulty concentrating, further complicating daily tasks. It is essential for individuals experiencing these symptoms to seek medical advice to manage their condition effectively.

o Cloudy eyesight.

Broken skin that often takes a long time to heal.

o Infections.

### 1.2 Diagnosis

1.5 Three tests are available to medical practitioners for the detection of prediabetes and diabetes. The numbers 5, 8, 13, 14, 15, and 16 refer to specific data points or categories relevant to the tests.: The haemoglobin A1C test, often known as the glycosylated haemoglobin test, can detect both diabetes and prediabetes. The average blood glucose management for the past 2-3 months is computed. Glycosylated haemoglobin (A1C) levels are a favourable indicator of blood sugar levels. This test is more convenient than others because fasting is not required. If an individual's A1C falls within the range of 5.7% to 6.4%, they are considered prediabetic and have a high chance of developing diabetes. A diabetic diagnosis is made when the A1C levels reach 6.5% or above.



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A fasting plasma glucose (FPG) test measures the amount of sugar (glucose) in the blood. A fasting plasma glucose test requires that you refrain from eating or drinking anything apart from water for eight hours before the test. It is necessary to draw blood for this examination.

Blood glucose is measured in milligrammes per decilitre (mg/dL).

One such test is the oral glucose tolerance test, which measures how well the body handles a standard dose of glucose. To finish the test, the subject needs to fast for at least eight hours, during which time they should only drink water. The healthcare provider will administer a glucose-containing beverage to the subject following the blood draw. Blood samples are obtained again at 30 and 60 minutes. The test might take three hours. The next step is for the doctor to monitor the plasma glucose levels both before and after administration.

These values are measured in milligrammes per decilitre.

### 1.3 Treatment and Follow up

Controlling blood sugar levels, making behavioural changes, and avoiding complications are the pillars on which diabetes care rests. Diabetes mellitus type 1 requires lifelong insulin therapy, but type 2 diabetes begins with dietary changes, exercise, and oral hypoglycaemics, and insulin therapy is introduced later on. In order to prevent serious complications, it is necessary to maintain a blood pressure level below 130/80 mmHg, control cholesterol levels, and monitor for neuropathy, nephropathy, and retinopathy annually. Injections of anti-VEGF medication, corticosteroids, or this laser treatment may be necessary to maintain vision in those with severe diabetic retinopathy. references [6, 7, 13, 15, 16].

### 1.4 Relationship of Diabetes Mellitus with Age and Gender

Gender and age have important roles in the development, course, and outcomes of diabetes mellitus (DM). Beyond the age of 40, the chance of developing Type 2 Diabetes Mellitus (T2DM) increases due to age-related metabolic changes, decreased insulin sensitivity, and pancreatic β-cell dysfunction. The prevalence of diabetic complications, including cardiovascular disease, nephropathy, and neuropathy, increases with age. Latent autoimmune diabetes in adults (LADA) may manifest later in life and is often mistaken for type 2 diabetes, while type 1 diabetes mellitus (T1DM) is more prevalent in children and young adults [3, 4, 16, 17]. Another factor that influences the likelihood of getting diabetes and its consequences is gender. Compared to women, males develop type 2 diabetes at a lower body mass index (BMI) due to the higher accumulation of visceral fat, which is directly associated with insulin resistance. On the other hand, hormonal and metabolic differences likely account for the increased relative risk of cardiovascular disease in females with diabetes as compared to males. Moreover, the chance of acquiring type 2 diabetes increases throughout a woman's life when she has gestational diabetes mellitus (GDM)—a condition that affects about half of all pregnant women. Some protection against diabetic complications may also be provided by hormonal factors; it seems that premenopausal women have 8



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Premenopausal women appear to be more resilient to these challenges. Midlife and older women are at increased risk for a variety of diabetes-related complications [3,11] since this protective effect clearly fades after menopause.

### 1.5 Diabetic retinopathy (DR)

One of the most serious microvascular consequences of diabetes is diabetic retinopathy (DR), which gradually damages the blood vessels in the retina and can lead to vision loss or blindness. This complication is present in both type 1 and type 2 diabetes, and the danger becomes more severe when the disease is left untreated for a long time. Retinal microaneurysms, haemorrhages, and capillary occlusion are hallmarks of non-proliferative diabetic retinopathy (NPDR). On the other hand, proliferative diabetic retinopathy (PDR) is a pathology where neovascularisation occurs, increasing the likelihood of vitreous haemorrhage and retinal detachment [7, 10], [12], [18], and [19].

Diabetic retinopathy usually affects both eyes. As diabetes persists for a longer period of time, the likelihood of developing diabetic retinopathy rises. If left untreated, diabetic retinopathy can cause blindness. The lens, which controls the eye's focus, might develop fluid buildup in diabetics due to long-term increased blood sugar levels. The eyesight is changed because the fluid accumulation changes the curvature of the lens. Once blood sugar levels are under control, the lens will usually return to its former shape, and eyesight will improve. If diabetic individuals can control their blood sugar levels better, diabetic retinopathy will start and progress more slowly [14], [19].

## Methods and Materials

### 2.1 Subjects and Data Collection

It would be beneficial to conduct a thorough study including all of these variables among diabetic mellitus patients in city, Diyala province, Iraq, to gain a better understanding of the disease's prevalence, the factors that influence it, the mechanisms by which it develops, and the complications it can cause, such as retinopathy. To accomplish this, it is vital to examine the potential modifications to those parameters. To kick off my experiment and lead me closer to my goal, I followed the ethical guidelines set out and collected data from September 2024 to January 2025 at the Hospital / Department of Ophthalmology in Diyala. We separated the 114 people who participated in our study into two categories: those who did not have diabetes mellitus (normal participants) and those who did. Each category contained distinct data points.

Hypertension, anaemia, nephropathy, HbA1c, hyperlipidaemia, hypertension, and the duration of diabetes mellitus were all factors included in the study. The study also explored the effects of gender, age, and weight on some of those factors. An Excel sheet was used to enter the parameters after the data was collected using a custom-constructed and filled-out form. Then, the Mat.file was extracted using MATLAB 2020. We used MATLAB for all of our statistical analysis and coding needs.

### 2.2 Statistical Analysis

Statistical evaluations were conducted using the Wilcoxon signed-rank test for hypertension, hyperlipidaemia, nephropathy, and total HbA1c levels. The Wilcoxon rank-sum test, commonly known as the Mann-Whitney test, was used to statistically analyse the effects of gender, weight, and



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age on those variables. This test is used to compare the means of two continuous distributions. Since it outperforms the two-sample t-test when dealing with non-normal distributions, we choose to employ it for our investigation. We used the Kolmogorov-Smirnov test to identify if our data follows a normal distribution by statistically comparing different sets of data. A p-value below 0.05 was considered statistically significant.

## Results and Discussion

### 3.1 Data Distribution Based on the Gender, Gender, and Weight factors

Our study included 104 data points, including 47 females (or 45% of the sample) and 57 males (or 55%), as illustrated in figure (3.1). You can trust the comparison and subtraction because the two percentages are close enough. Out of the 104 participants surveyed, 48 were found to be female and 52% to be male with diabetes mellitus. The second group, which contained information from those without diabetes, had a slightly lower rate. Figure (3.1) shows that 75% of the participants were female. The 104 data points were organised into six categories, based on age and gender. The age range of 50-60 years old had the largest percentage at 38%, followed by the 40-50 years old group at 33% and the 60-70 years old group at 18%. Figure (3.2) shows that the age segment from 70 to 80 years old had 7% of the total, while the age subgroups from 1 to 30 and 70–80 years old had the lowest percentages at 2% and 1%, respectively. There were six age categories among the subjects with diabetes mellitus: 1-30, 30-40, 40-50, 50-60, 60-70, and 70-80 years old. The age distribution of the participants was as follows: 41% were in the 50–60 age bracket, 32% were in the 40–50 age bracket, and 20% were in the 60–70 age range. In that group, 7% were in the 30–40 age bracket, 2% were in the 1–30 age bracket, and 1% were in the 70–80 age bracket, as shown in figure (3.2). Among the healthy individuals who did not have diabetes, 42% were in their 30s and 40s, 25% were in their 1st to 30s, 17% were in their 40s and 50s, and 8% were in their 60s and 70s. This distribution shows that there is a variety of ages and the number of patients in each, with a maximum of fourteen patients per age group. Individuals in these age groups do not have data that follows the normal distribution required for the t-test, making it difficult to apply this statistical method.

We began by examining our data distribution by weight factor, as it is widely acknowledged that there is a strong correlation between diabetes mellitus and weight. There were eight weight groups for all sample data points, as shown in Figure (3.3). The greatest percentage was 34% for participants with 70-80 kg, followed by 22% for 90-100 kg, 19% for 80-90 kg, and 14% for 60-70 kg. The percentages were 4% for the 100-110 kg group, 2% for the 110-120 kg group, and 1% for the 120-130 kg group. The last group included 4% of the population, with a weight of 50–60 kg. Classical tests, such as the t-test, have a challenging time making sense of the data because of the large variation in the weight range. Individuals weighing 70–80 kg, 80–90 kg, 90–100 kg, and 60–70 kg had the largest percentages of weight among diabetes mellitus patients, with 36, 21, and 11% of those individuals, respectively, falling into those categories. Participants weighing between 100 and 110 kg, 110 and 120 kg, 120 and 130 kg, and 50-60 kg made up the other weight groupings with the lowest percentages, at 4%, 2%, 1%, and 4%, respectively. Lastly, the percentages of normal participants who did not have diabetes mellitus varied as follows: 42%, 17%, 8%, and 33%; the weight ranges for these individuals were 50-60 kg, 60-70 kg, 70-80 kg, and 80-90 kg, respectively. Weight is a factor that affects and plays a part in developing diabetes mellitus disease in all three



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groups: total, diabetes mellitus, and normal. Understanding these correlations is crucial for developing effective prevention strategies. Further research is needed to explore the underlying mechanisms that link weight to diabetes risk across different population segments. This lends credence to the numerous studies that have shown obesity or excessive weight gain to be the leading cause of diabetes mellitus (DM), namely type 2, in people of all ages.


Figure 3.1:Data distribution based on gender factor.

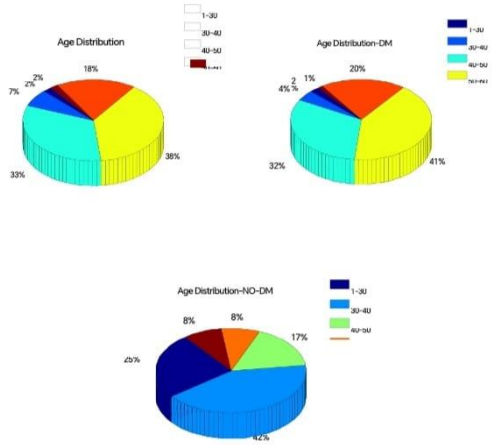


Figure 3.2: Data distribution based on Age factor.

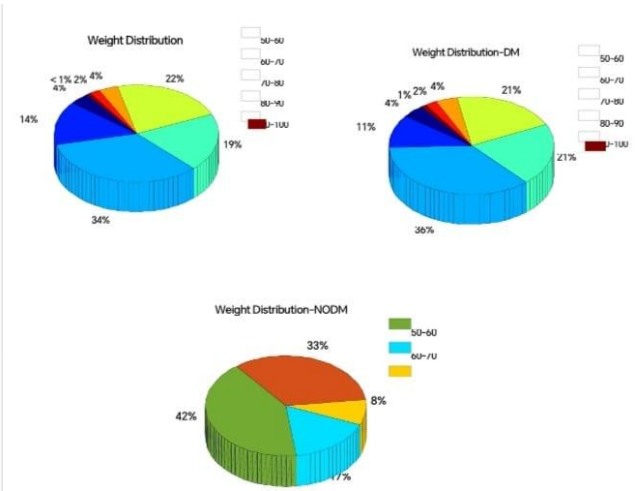


Figure 3.3: Data distribution based on weight factor.

### 3.2 HbA1c and Diabetes Mellitus

Glycated hemoglobin (HbA1c) which was first recognized many years ago as abnormal hemoglobin in diabetic patients. It is a measure of the average plasma glucose levels for the preceding eight to twelve weeks. In contrast to the controls, who had a HbA1c of 4.7, our results indicated that the HbA1c was about 9, as we know that a point of impact of 6.5% is advised for the diagnosis of diabetes. The shift of the red trace of the empirical cumulative distribution function plot (ecdf) in



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figure 3.4 shows the data points of our data from lowest to highest versus their percentiles. Here, we are focused on 50 percentiles to obtain the bA1c measurement. We employed the Kolmogorov Smirnov test for statistical analysis in order to compare the two distributions (Controls and DM), and the results showed that the HbA1c values differed significantly (p-value < 0.05).

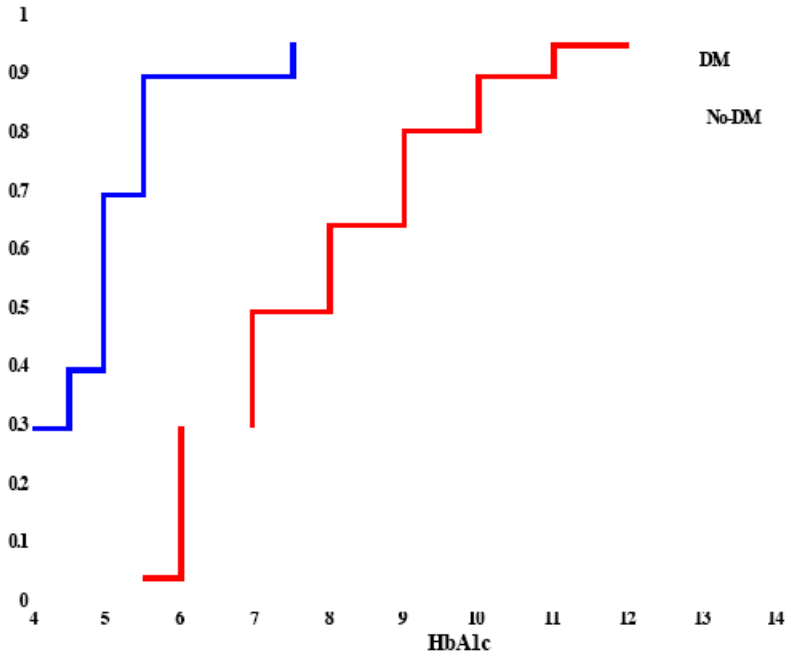


Figure 3.4: ECDF of the HbA1c for both DM patients and Controls.

It is clear that there is a significantdifference between the two distributions as one can notice by the shift of the red trace to have value of
8 on x-axis which represents the HbA1c. The significant difference was confirmed by applying (KS-test), with p-value less than 0.05.

### 3.3 Hypertension, Hyperlipidemia, Anemia, Neuropathy and Heart Diseases in DM patients

Since individuals who have diabetes are twice as likely to have hypertension than those without the disease, and as those with hypertension are more likely to develop insulin resistance and diabetes than individuals without the disease, we examined the related hypertension in both groups and compared them. Our data revealed that out of 93 patient with DM, there were 61 with hypertension and 23 with other associated heart diseases such as angina, cardiac arrhythmia, and chest pain which was not unexpected. Since hyperlipidemia is well known to be associated with DM patients, our data examined this point and we found that 50 patients with DM had hyperlipidemia as well, see table (3.1). egarding anemia and nephropathy, our data showed that there were only 17 and 7 patients who had a nemia and nephropathy respectively and as shown in the table 3.1.



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Table 3.1: Hypertension, Hyperlipidemia, Anemia, Neuropathy and Heart Diseases in DM patients

| Variable | DM | | No-DM | |
|---|---|---|---|---|
| | YES | NO | YES | NO |
| Hypertension | 61 | 32 | 5 | 7 |
| Hyperlipidemia | 50 | 42 | 3 | 9 |
| Anemia | 17 | 75 | 0 | 0 |
| Nephropathy | 7 | 85 | 0 | 0 |
| Heart Diseases | 23 | 69 | 2 | 10 |

### 3.4 Effect of Age Factor on HbA1c

Figure 3.5 shows that there are variations in the value of HbA1c within the age. The age groups that were considered here to investigate the age effect were: '30-40', '40-50','50-60' ,'60-70','70-80','80-90' respectively which were displayed as: 1, 2, 3, 4, 5, and 5 groups on x-axis and their corresponding values of HbA1c were displayed on the series "1" row. Obviously, there is a general reduction trend as patients go from age range of '30-60' to older ranges with some ups and downs that could be the effect of some other factors including gender, obesity, and some other associated diseases.

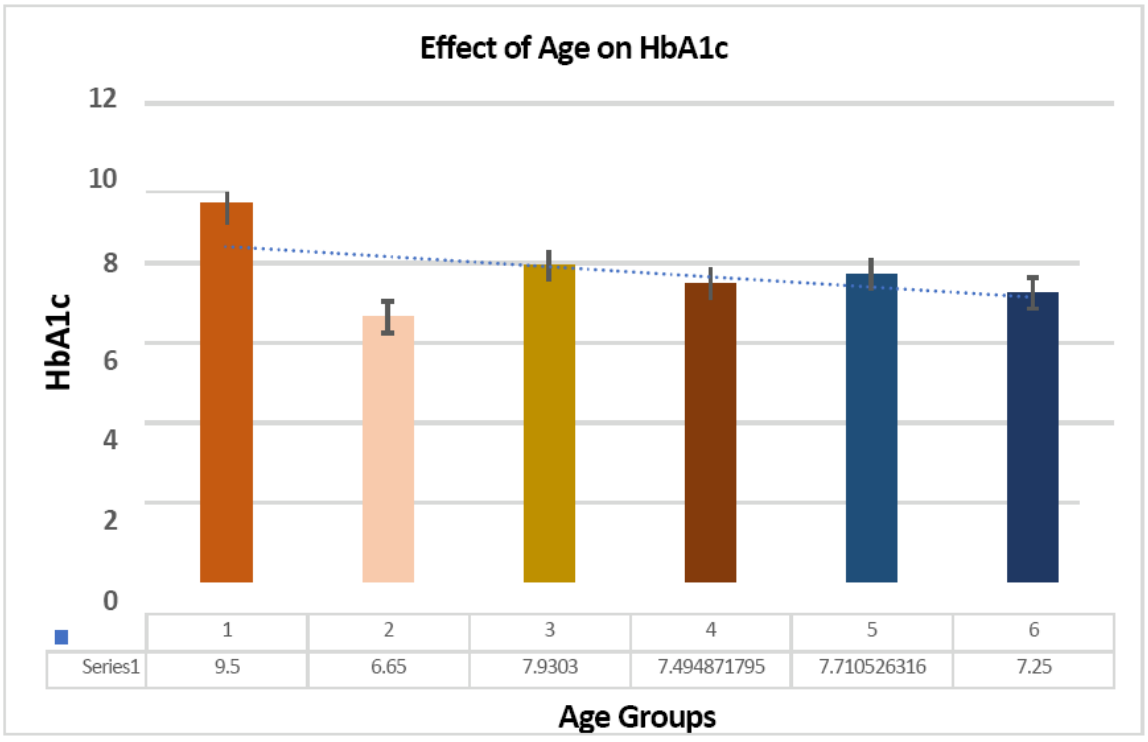


Figure 3.5: Effect of Age on HbA1c. A general reduction trace is evident with some variations after age of

### 3.5 Effect of Gender Factor on HbA1c

While there are some conflicts about the effect of gender on HbA1c values as some studies have documented that there is no effect and others reported that HbA1c is higher in males compared than females, our data showed that it is higher in males than females, the data revealed that while HbA1c value was 7.57 in females, it was 7.73 in males. Though, it didn't reach the level of significance (p-value >0.05, Mann-Whitney test) but there is a clear difference between the two groups as shown in figure (3. 6).

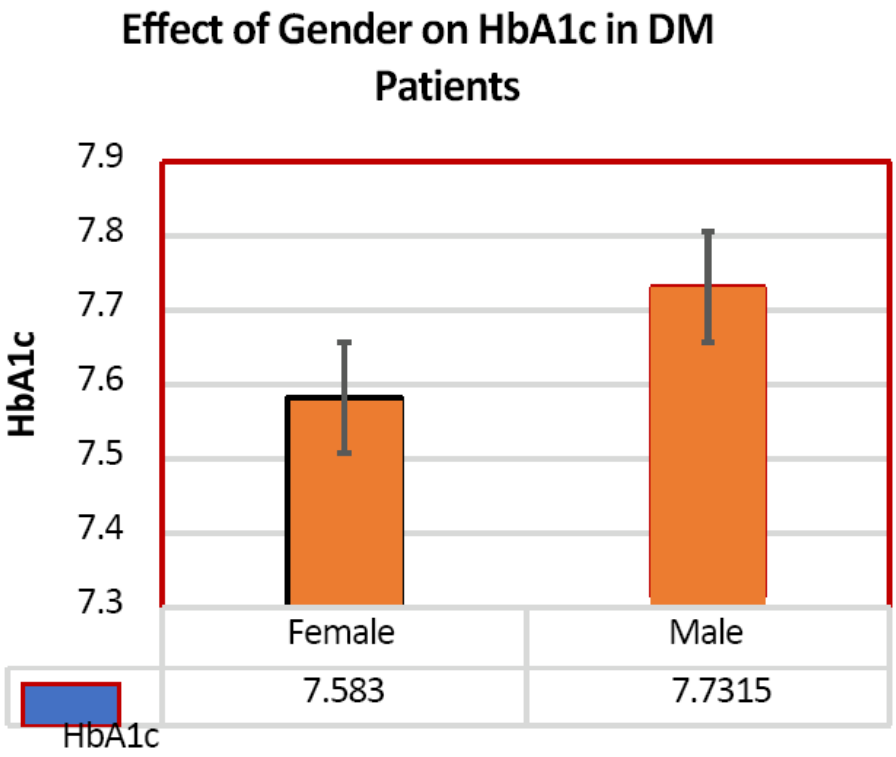


Figure 3.6: Effect of Age on HbA1c.

### 3.6 Effect of Weight Factor on HbA1c

According to figure 3.6, there are variances in the HbA1c value within the weight. In this study, the weight groups that were taken into consideration to examine the weight effect were: 60-70', 70-80', 80-90', 90-100', 100-110', and 110-120' kg respectively. These groups were shown as 1, 2, 3, 4, 5, and 6 on the x-axis, and the series "1" row showed the corresponding values of HbA1c. It is evident that there is a general upward tendency as patient weights rise, which makes sense, with occasional fluctuations that might be caused by other variables. We may observe that the increase becomes considerably more noticeable when the weight exceeds 100 kg. The t-test has shown a significant difference with a p-value of less than 0.05.



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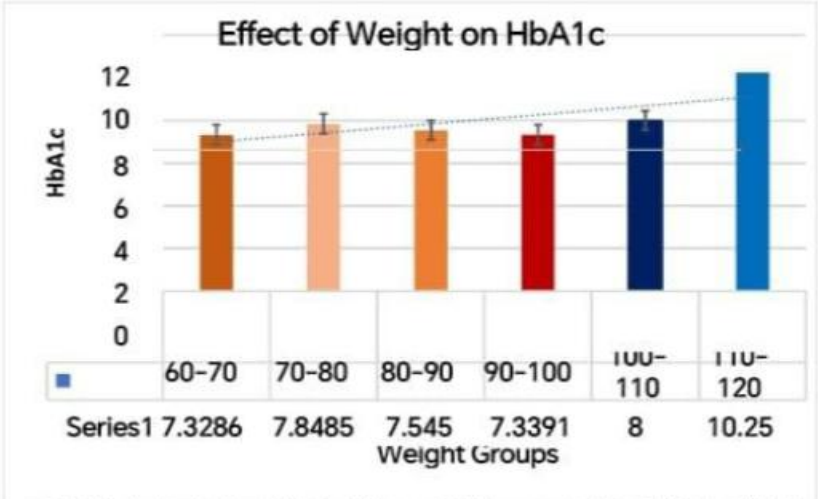


Figure 3.7: Effect of weight on HbA1c. More weight is associated with higher HbA1c value.

Figure 3.7: Effect of weight on HbA1c. More weight is associated with higher HbA1c value.

**Conclusions and Future Directions**

Despite their shared prevalence, vascular risk factors may have distinct effects on various organ systems.

These risk factors coexist and share comparable impacts, including atherosclerosis. For example, harm to endogenous kidney and retina organs is substantially associated with type 2 diabetes and hypertension via pathophysiological processes that are at least largely distinct from one another. Injuries to the kidneys and retina are associated with obesity, which in turn causes dyslipidaemia. Based on our findings, individuals with diabetes mellitus are more likely to have hyperlipidaemia and hypertension when compared to healthy controls. Furthermore, the data showed that gender, weight, and age significantly influence the HbA1c. Our findings suggest that HbA1c readings are age- and gender-dependently increasing. Health care providers who have this knowledge will be able to help their patients in a more personalised and efficient way. Additionally, this study has the potential to expand our understanding of age-related physiological changes and diabetes mellitus. Consequently, this study's findings can contribute to the advancement of medical knowledge as a whole and have practical consequences in the clinic.

Considering the study's limitations, such as insufficient data on retinopathy and nephrology, and its overall scope, the following important next steps can be proposed:For more accurate results on changes in the associated disorders, it would be advantageous to have a bigger sample size. Additionally, by analysing age and gender factors using a two-way ANOVA, we can learn more about the management.



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