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Comparison of Glycosylated Hemoglobin in Type 1 and Type 2 Diabetes

Abstract

The aim of this study is to examine the relationship between glucose metabolism, insulin resistance, and glycated hemoglobin (HbA1c) levels in individuals with Type 1 and Type 2 diabetes. The study was conducted on 100 participants aged 13 to 78 years, categorized into two groups based on age for comparative analysis. Individuals aged 13–30 years were assessed for Type 1 diabetes, while those aged 31–78 years were analyzed for Type 2 diabetes.

It has been shown that in individuals with Type 1 diabetes, insulin deficiency leads to elevated glucose and HbA1c levels, while in Type 2 diabetes, insulin resistance and β-cell dysfunction play a significant role in disease progression. The study determined that men had higher fasting glucose and HbA1c levels compared to women, which may be associated with hormonal, genetic, and metabolic factors. It was also noted that in cases of high insulin resistance, increased HbA1c levels were observed, emphasizing the effect of prolonged hyperglycemia on diabetes progression.

The results indicate that Type 2 diabetes is more common than Type 1 diabetes, particularly in older individuals, due to age-related insulin resistance and β-cell dysfunction. Type 1 diabetes, on the other hand, is primarily caused by autoimmune destruction of β-cells and is more prevalent in younger individuals. The findings confirm that early diagnosis and individualized treatment strategies are essential for effective diabetes management. The role of biochemical markers such as glucose, insulin, and HbA1c levels in assessing disease progression and metabolic control has been highlighted, demonstrating the importance of continuous monitoring in diabetes care.

Keywords: *Diabetes mellitus, Type 1 diabetes, Type 2 diabetes, Insulin resistance, Glycohemoglobin*

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Tip 1 və tip 2 diabetdə qlikosilləşdirilmiş hemoglobinin müqayisəsi

Xülasə

Bu işin məqsədi Tip 1 və Tip 2 diabetli şəxslərdə qlükoza metabolizmi, insulin müqaviməti və qlikozid hemoglobin (HbA1c) səviyyələri arasındakı əlaqəni araşdırmaqdır. Tədqiqat yaşı 13-dən 78-ə qədər olan 100 iştirakçı üzərində aparılıb, müqayisəli təhlil üçün yaşa görə iki qrupa bölünüb. 13-30 yaş arası şəxslər 1-ci tip şəkərli diabet üçün, 31-78 yaşlılar isə Tip 2 diabet üçün təhlil edilib.

Göstərilmişdir ki, 1-ci tip diabetli şəxslərdə insulin çatışmazlığı qlükoza və HbA1c səviyyələrinin yüksəlməsinə səbəb olur, 2-ci tip diabetdə isə insulin müqaviməti və β-hüceyrə funksiyasının pozulması xəstəliyin irəliləməsində mühüm rol oynayır. Tədqiqat kişilərin qadınlara nisbətən daha yüksək oruc qlükoza və HbA1c səviyyələrinə sahib olduğunu müəyyən etdi ki, bu da hormonal, genetik və metabolik faktorlarla əlaqəli ola bilər. Həmçinin qeyd olunub ki, yüksək insulin müqaviməti hallarında HbA1c səviyyəsinin yüksəlməsi müşahidə olunub, uzun müddət davam edən hiperqlikemiyanın diabetin gedişatına təsirini vurğulayır.

Nəticələr göstərir ki, yaşa bağlı insulin müqaviməti və β-hüceyrə disfunksiyasına görə Tip 2 diabet, xüsusilə yaşlı insanlarda Tip 1 diabetdən daha çox rast gəlinir. Digər tərəfdən, 1-ci tip diabet, ilk növbədə, β-hüceyrələrin otoimmün məhvindən qaynaqlanır və daha çox gənc fərdlərdə rast gəlinir. Nəticələr təsdiqləyir ki, erkən diaqnoz və fərdi müalicə strategiyaları diabetin effektiv idarə olunması üçün vacibdir. Xəstəliyin gedişatının və metabolik nəzarətin qiymətləndirilməsində qlükoza, insulin və HbA1c səviyyələri kimi biokimyəvi markerlərin rolu vurğulanmışdır ki, bu da diabetə qulluq zamanı davamlı monitorinqin vacibliyini nümayiş etdirir.

Açar sözlər: *Diabetes mellitus, 1-ci tip diabet, tip 2 diabet, insulin müqaviməti, qlikohemoqlobin*

Introduction

Diabetes Mellitus is a chronic metabolic disease characterized by elevated blood glucose levels. This condition affects millions of people worldwide and leads to serious health complications. The development of diabetes is primarily associated with either inadequate insulin production or the body's resistance to insulin. Insulin is a crucial hormone that facilitates the uptake of glucose from the bloodstream into cells, where it is used as an energy source. A deficiency or dysfunction of insulin results in elevated blood sugar levels. There are two primary types of diabetes mellitus: Type 1 diabetes and Type 2 diabetes. The underlying mechanisms, causes, and clinical characteristics of these two types differ significantly. If left unmanaged, diabetes can lead to severe complications, including cardiovascular diseases, kidney failure, nervous system damage, and vision impairment (Shaw, Bannuru, & Beach, 2024).

Research

Type 1 Diabetes

Type 1 diabetes is an autoimmune disease that occurs as a result of the body's immune system destroying the beta cells of the pancreas. These cells produce the hormone insulin, and their damage leads to insulin deficiency in the body. In type 1 diabetes, the complete cessation of insulin production indicates the body's difficulty in regulating blood glucose levels. In this type of diabetes, the level of glycated hemoglobin (HbA1c) is a key indicator of how effectively the disease is being managed. High HbA1c levels reflect inadequate diabetes control and indicate the effects of prolonged hyperglycemia on the body. Although insulin resistance is rare in type 1 diabetes, some individuals may develop resistance to insulin, leading to increased HbA1c levels. In particular, increased insulin resistance can make blood sugar regulation more difficult, resulting in higher HbA1c levels and an increased risk of associated complications (Neumiller, Bajaj, Bannuru, & McCoy, 2025).

Features:

- It is more common in children and young adults.
- Insulin production stops completely.

- Patients have to take insulin injections for the rest of their lives.
- It manifests itself with symptoms such as weight loss, excessive thirst, frequent urination, and fatigue.

Reasons:

- Genetic predisposition
- Viral infections (e.g., measles, cytomegalovirus)
- autoimmune factors

Type 2 Diabetes

Type 2 Diabetes Mellitus (T2DM) is a chronic metabolic endocrine disorder characterized by peripheral tissue resistance to insulin or inadequate insulin secretion by pancreatic beta cells. This pathological condition primarily arises due to impaired insulin uptake by peripheral organs—such as skeletal muscles, the liver, and adipose tissues. As a result of insulin resistance, intracellular glucose uptake decreases, leading to hyperglycemia. Additionally, although pancreatic β-cells attempt to compensate by producing more insulin, this excessive activity gradually results in β-cell dysfunction. Consequently, insulin secretion declines, leading to insulin deficiency and the development of a clinical state characterized by impaired glucose regulation (Zhou, Egeland, & Meltzer, 2016).

Elevated glycated hemoglobin (HbA1c) levels serve as a biomarker for poor glycemic control in type 2 diabetes, often resulting from prolonged hyperinsulinemia. HbA1c is a complex compound formed by the interaction between glucose and hemoglobin in the blood, and its increased levels indicate chronic hyperglycemia. Higher HbA1c levels are associated with worsening insulin resistance and reflect the long-term adverse effects of poorly managed diabetes on the body, including vascular complications, kidney disease, and nerve damage. Additionally, the study of insulin resistance plays a crucial role in assessing the degree of β-cell dysfunction and evaluating the natural progression of diabetes (John, Mosca, Weykamp, et al., 2007).

Features:

- It is usually found in people who are obese.
- There is insulin resistance, which means the body does not respond properly to insulin.
- Symptoms progress slowly and may not be detected in the early stages.
- Patients may not always need insulin injections, but they may use medication in pill form, along with a proper diet and physical activity.

Reasons:

- Genetic predisposition
- Overweight and obesity
- Lack of physical activity
- Poor nutrition and excessive use of sweet, fast food

Research on Type 1 and Type 2 diabetes has revealed significant differences in patients' age groups and metabolic parameters. In this context, the present study aims to conduct a comparative analysis of the clinical and laboratory parameters of diabetes across different age groups (American Diabetes Association, 2011).

Research

This study was conducted on a total of 100 participants aged between 13 and 78 years. Fasting blood glucose and glycated hemoglobin (HbA1c) analyses were performed using the AU 480 analyzer, while insulin levels were measured using the UniCel Dxl 600 analyzer. Insulin resistance indices were determined by dividing the product of glucose and insulin values by 405. As part of the study, participants were categorized into two main age groups. Individuals aged 13–30 years were grouped for the comparative analysis of Type 1 diabetes, whereas those aged 31–78 years were analyzed for Type 2 diabetes. In total, 21 participants were in the 13–30 age group, while 79 participants were in the 31–78 age group (Bookchin, Gallop, 1968).

Among the 21 participants aged 13–30 years, 18 were assigned to the control group, while 3 were diagnosed with Type 1 diabetes. In the control group, 72.2% (n=13) were female, with an average fasting glucose level of 85 mg/dL. The remaining 27.8% (n=5) were male, with an average fasting glucose level of 84 mg/dL. Among the 3 individuals with Type 1 diabetes, 2 were female, and 1 was male. The average fasting glucose level in this group was 128 mg/dL, ranging from 102 mg/dL to 152 mg/dL. Additionally, in the control group, the average glycated hemoglobin (HbA1c) level for 72.2% (n=13) of participants was 5.2%, while for 27.8% (n=5) of males, it was 5.0%. In individuals with Type 1 diabetes, the average HbA1c level was 6.3%. In this group, a 16-year-old female participant had a normal HbA1c level of 5.4%, while the highest recorded value was 6.8% in a 13-year-old male participant. A 29-year-old female participant had an HbA1c level of 6.7% (March, Sherman, Bannuru, Fischer, Gabbay, 2023).

Insulin (fasting) and insulin resistance (HOMA-IR) analyses were also performed in individuals with type 1 diabetes. According to the results:

• A 16-year-old female with a glycohemoglobin level of 5.4% had fasting insulin of 29.77 uU/ml and insulin resistance of 7.5.

• A 13-year-old male with a glycohemoglobin level of 6.8% had fasting insulin of 15.84 uU/ml and insulin resistance of 5.08.

• A 29-year-old female with a glycohemoglobin level of 6.7% had fasting insulin of 57.05 uU/ml and insulin resistance of 21.41.

Among the 79 participants aged 31–78 years, 27 were diagnosed with Type 2 diabetes, while 52 were assigned to the control group. In the control group, 61.5% (n=32) were female, with an average fasting glucose level of 89 mg/dL. Among 38.5% (n=20) of male participants, the average fasting glucose level was 96 mg/dL. Among the 27 individuals with Type 2 diabetes, 44.4% (n=12) were female, with an average fasting glucose level of 128 mg/dL, while 55.6% (n=15) were male, with an average fasting glucose level of 156 mg/dL. In the control group, the average glycated hemoglobin (HbA1c) level was 5.3% in females and 5.5% in males (Genuth, Alberti, Bennett, et al., 2003). Among participants with Type 2 diabetes, the average HbA1c level was 6.6% in females and 6.8% in males. Among female participants with Type 2 diabetes, HbA1c levels were within the normal range in 5 individuals, while 7 had elevated levels. The highest recorded HbA1c value in this group was 11.1%, while the lowest was 5.4%. Among male participants, 8 had normal HbA1c levels, whereas 7 had elevated levels, with the highest recorded HbA1c being 11.6% and the lowest 5.1%. An interesting finding was that two individuals in the control group exhibited normal fasting glucose levels but had elevated HbA1c levels. Specifically, a 55-year-old female had an HbA1c level of 6.3%, while a 67-year-old male had an HbA1c level of 6.8% (Leslie, Palmer, Schloot, Lernmark, 2016).

Insulin (fasting) and insulin resistance (HOMA-IR) analyses were performed in 27 patients with type 2 diabetes.

• The average insulin level was 10.98 uU/ml.

• Out of 27 patients, 4 had insulin levels above normal, while 22 had them within normal limits.

• Out of 4 patients with high insulin levels, 3 had high glycohemoglobin levels, while 1 had them within normal limits.

The average insulin resistance index was 3.86. Of the 13 people in this group with insulin resistance, 10 had high glycohemoglobin and 3 had normal levels (Skyler, Bakris, Bonifacio, Darsow, Eckel, Groop, et al., 2017).

The results of the study showed that type 2 diabetes is more common than type 1 diabetes and is especially common in older people. This can be explained by the age-related increase in insulin resistance and pancreatic β-cell dysfunction. Type 1 diabetes, on the other hand, develops mainly as a result of autoimmune pathogenesis and is more common in young people (World Health Organization, 1999).

The results of the study showed that glucose and glycohemoglobin levels in men are significantly higher than in women. These differences may be related to hormonal effects, metabolic differences, and genetic factors. At the same time, it was also statistically confirmed that the clinical course of insulin resistance and hyperglycemia is more severe in men (Sultanpur, Deepa, & Kumar, 2010).

In cases of high insulin resistance, an increase in glycated hemoglobin (HbA1c) levels was observed, highlighting the role of sustained hyperglycemia in the progression of diabetes. Variations in individual responses to insulin were noted among patients, which may explain different aspects of metabolic adaptations.

The results indicate that the manifestation of diabetes across different age groups and genders underscores the need for personalized treatment strategies. This study highlights the importance of early diagnosis and the implementation of individualized therapeutic approaches in diabetes management. Furthermore, the clinical significance of biochemical analyses related to insulin secretion and resistance can be considered a critical factor in improving diabetes prognosis (Zimmet, Alberti, & Shaw, 2001).

Conclusion

The results of the conducted research revealed clinical, biochemical, and demographic differences between Type 1 and Type 2 diabetes. The wider prevalence of Type 2 diabetes in the population, particularly among older individuals, indicates the significant role of metabolic factors and lifestyle in the pathogenesis of the disease. The data obtained confirm that insulin resistance and β-cell dysfunction increase with aging, leading to a gradual rise in blood glucose levels.

On the other hand, Type 1 diabetes was found to be primarily autoimmune in nature and more commonly observed in younger age groups, emphasizing once again that the autoimmune destruction of β-cells is a key factor in the disease's development. The study also demonstrated that glucose and glycated hemoglobin levels were higher in males compared to females, which could be explained by genetic and hormonal factors.

Furthermore, the impact of insulin resistance and hyperglycemia on the clinical course of the disease was statistically confirmed. Elevated glycated hemoglobin levels and increasing insulin resistance play a significant role in the progression of diabetes, highlighting the importance of early detection of the disease.

Overall, this study provides a scientific basis for understanding how diabetes manifests in different age and gender groups and for developing personalized treatment strategies for the disease. Future research should focus on a deeper analysis of genetic and metabolic factors and the evaluation of the effectiveness of new therapeutic approaches.

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