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Comparative Evaluation of Maternal Age, Hemoglobin, and Random Blood Glucose Levels in Women with and Without Gestational Diabetes Mellitus in Najaf Province, Iraq

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ABSTRACT

Background: Gestational diabetes mellitus (GDM) is one of the commonest diseases during pregnancy with significant adverse effect on mother and fetus. Assessment of biochemical parameters like hemoglobin (HG) and random blood glucose (RBG) is essential to understand better the nature of the disease.

Objectives: to compare maternal age, hemoglobin and random blood glucose among women with and without gestational diabetes mellitus.

Materials and Methods: A case-control study design was performed among 100 pregnant women attending Al-Zahraa Teaching Hospital, Najaf, Iraq, during the period from January to June 2026. This study compared 70 pregnant women with gestational diabetes mellitus and 30 pregnant women without gestational diabetes mellitus. The participants' maternal age, hemoglobin and random blood glucose levels were extracted from the hospital's medical records. The statistical analysis was achieved by applying the descriptive and inferential statistical tests. The p-value was considered statistically significant at $p<0.05$.

Results: The mean age of mothers diagnosed with GDM was significantly lower than that of mothers with healthy pregnancy, (28.49 ± 6.89 vs. 31.90 ± 7.70, respectively; P=0.041). Hemoglobin concentration was lower in the GDM group than in the control group (9.90±1.50 vs. 10.35±2.21, respectively). however, the difference was not statistically significant (P = 0.291). At the same time, random blood glucose levels were considerably higher in women diagnosed with GDM than in the control group (263.34 ± 50.93 vs. 107.77±13.56, respectively; P<0.001). The diagnostic accuracy of RBG was found to be highly efficient by ROC analysis, with AUC being 1.000, 100% and 100% for sensitivity and specificity, respectively. Correlation analysis showed that the association between hemoglobin and RBG was weak negative and non- significant (r= -0.139, P=0.168) while showed that the association between maternal age vs. hemoglobin was positive (r= 0.367, P <0.001).

Conclusion: the study indicates that proper management of hyperglycemia and anemia may improve pregnancy outcomes and reduce the risk of obstetric and neonatal complications.

KEYWORDS: Gestational diabetes mellitus; Random blood glucose; Hemoglobin; Pregnancy; Biochemical markers.

1. INTRODUCTION

Gestational diabetes mellitus (GDM) is a common metabolic disease characterized by glucose intolerance diagnosed during pregnancy [1]. Its incidence is increasing worldwide by 1-28% during recent years due to changes in female demographics [2]. Diagnosing GDM is a challenging process since it not only damages maternal wellbeing but also leads to fetal hyperglycemia, resulting in macrosomia, preterm birth, cesarean delivery, and chronic metabolic disorders for both mother and child [3].

The disorder of gestational diabetes mellitus (GDM) has become more rampant over the past two decades due to risk factors such as obesity, physical inactivity, maternal age and the shift in diagnostic criteria as depicted in Figure 1. Current estimates suggest that about 1 out of 6 pregnancies is complicated by hyperglycemia; moreover, gestational diabetes mellitus (GDM) is considered to be the most widespread manifestation of this disease during pregnancy [4]. GDM often develops when a woman is diagnosed to be late pregnant or when her gestation age progresses [5]. Women belonging to the older age group (>30 years) are more likely to develop GDM and pregnancy complications as compared to those in the 20–24 years' category [6]. Women with diagnosed type 1 diabetes mellitus (T1D) or type 2 diabetes mellitus (T2D) and those with a family history of gestational diabetes mellitus/diabetes mellitus (GDM/DM) are at particular risk of developing GDM. The development of gestational diabetes is closely associated with obesity, body mass index (BMI), diet, nutritional intake, and calorie consumption. Pregnant women with a body mass index (BMI) ≥29.0 kg/m^2 are more likely to develop gestational diabetes mellitus (GDM) and pregnancy complications compared to those with

lower BMI [7]. Women diagnosed with PCOS and multiple pregnancies have twice higher risk for developing GDM and metabolic complications [8].

Figure:1 Risk factors of gestational diabetes mellitus (GDM) development.

The pathophysiology of gestational diabetes mellitus (GDM) is marked by progressive insulin resistance that occurs during pregnancy. This is caused by hormones produced by the placenta such as human placental lactogen, progesterone, cortisol and placental growth hormone. This resistance is usually offset by increased secretion of insulin by pancreatic β-cells. In susceptible women, this compensatory mechanism is inadequate and maternal hyperglycaemia ensues. Hyperglycemia has a direct effect on fetal growth and maternal outcomes, hence early recognition and proper monitoring are an integral part of antenatal care [9]. The oral glucose tolerance test (OGTT) is still the gold standard and reference method for the diagnosis of gestational diabetes mellitus [10]. However, the routine biochemical tests including random blood glucose (RBG) are still being explored as adjunct laboratory parameters to assess glycemic status and to identify women needing further metabolic evaluation, particularly in resource-constrained healthcare settings. In the present study, the diagnosis of gestational diabetes mellitus was made by OGTT, while blood glucose random was only measured as a comparative biochemical parameter between women with and without GDM, and not as a diagnostic test [11].

Random blood glucose (RBG) measurement is one of the simplest laboratory investigations routinely performed in many health care facilities [12]. RBG is less time consuming and more convenient to implement in busy outpatient clinics and resource limited settings as compared to OGTT and is not fasting dependent [13].

Recently, more attention has been paid to hematological parameters especially hemoglobin concentration as a potential biomarker associated with gestational diabetes [14]. Hemoglobin is routinely measured during antenatal visits to assess maternal anemia, but recent evidence suggests that it may also reflect metabolic changes associated with insulin resistance [15]. Elevated hemoglobin levels can contribute to increased iron stores, decreased plasma volume expansion, oxidative stress, and chronic low-grade inflammation, which are factors that reduce insulin signaling and glucose utilization [16]. Low hemoglobin levels due to iron deficiency anemia can also affect glucose metabolism through several mechanisms, making the association between hemoglobin levels and gestational diabetes mellitus (GDM) complex and multifaceted [17]. Several recent systematic reviews and meta-analyses have provided additional evidence of an association between selected hematological indices and gestational diabetes [18,19]. In particular, another meta-analysis published in 2025 found that compared with women without GDM, those with GDM had higher levels of hemoglobin, red blood cells, white blood cells, neutrophils to lymphocytes ratio, and mean platelet volume in the second trimester [20]. These findings suggest that routine hematological tests have potential beyond their established clinical role by helping to identify women at risk for developing gestational diabetes [18,19].

Despite this, there is still inconsistency in the relationships between hemoglobin levels and gestational diabetes in different populations [21]. The ethnic differences, nutritional status, iron supplementation, altitude, socio-economic factors, and health care systems are also reported to affect maternal hemoglobin status and glucose metabolism [22]. Consequently, evidence obtained in one population cannot always be extrapolated to another [23]. Regional studies are therefore needed to assess the consistency of the

association under local demographic and clinical conditions [24]. Especially in countries such as Iraq, there is a need for more research on gestational diabetes, including the latest studies in the Najaf Province [25].

In order to compare hemoglobin concentration and random blood glucose levels between pregnant patients with gestational diabetes mellitus and healthy pregnant patients visiting Al-Zahraa Teaching Hospital in Najaf Province, Iraq, the current case-control study was carried out. The aim also of this study to assess the relationship between gestational diabetes and hemoglobin concentration and to ascertain whether routinely obtained laboratory indicators could offer useful information for identifying women at higher metabolic risk.

2. MATERIALS AND METHODS

2.1 Study Design and Setting

A case-control study was conducted at Al-Zahraa Teaching Hospital, Najaf Province, Iraq, between January and June 2026.

2.2 Study Population and Sampling

Convenience sampling was used to enroll 100 pregnant women who visited the prenatal clinic during the study period. Participants were divided into 70 pregnant women diagnosed with gestational diabetes mellitus (GDM) and 30 healthy pregnant women without GDM. The participants' maternal age, hemoglobin and random blood glucose levels were extracted from the hospital's medical records.

The 75 g Oral Glucose Tolerance Test (OGTT) was used to diagnose GDM in accordance with the International Association of Diabetes and Pregnancy Study Groups' (IADPSG) diagnostic criteria.

2.3 Inclusion Criteria

Participants were included of the following criteria:

* Pregnant women aged (16–45 years).
* Singleton pregnancy.
* Complete demographic and laboratory records.
* Diagnosis confirmed by OGTT.
* Willingness to participate in the study.

2.4 Exclusion Criteria

Participants were excluded of the following criteria:

* Pre-existing type 1 or type 2 diabetes mellitus.
* Chronic renal disease.
* Chronic liver disease.
* Hemoglobinopathies or severe anemia.
* Multiple pregnancy.
* Autoimmune or endocrine disorders affecting glucose metabolism.
* Incomplete medical records.

2.5 Data Collection

A standardized data collection sheet was used to gather laboratory and demographic data from hospital records. The variables listed below were noted: Age of the mother (years), the concentration of hemoglobin (g/dL),
RBG (random blood glucose) (mg/dL), GDM status (control/case).

2.6 Blood Sample Collection

Each participant had about 3–5 mL of venous blood drawn from them under aseptic conditions by skilled lab personnel.

2.7 Laboratory Measurements

An automated hematology analyzer (Sysmex XN-1000, Sysmex Corporation, Kobe, Japan) was used to measure hemoglobin concentration. An automated clinical chemistry analyzer (Mindray BS-240 Pro, Mindray Bio-Medical Electronics Co., Shenzhen, China) was used to measure random blood glucose concentration using the glucose oxidase-peroxidase (GOD-POD) method in accordance with the manufacturer's recommendations. Standard internal quality-control procedures were carried out prior to sample analysis to guarantee analytical accuracy and precision.

2.8 Statistical Analysis

The data were analyzed using IBM SPSS Statistics version 26. The normality of the data was assessed using the Shapiro–Wilk test. The continuous variables were reported as Mean ± Standard Deviation (SD). Independent Samples T-test was applied to compare the means of the two groups while Categorical variables were compared using the Chi-square test.

The diagnostic accuracy of the random blood glucose (RBG) was determined using the receiver operating characteristic (ROC) curve analysis. The area under the curve (AUC), the cutoff value, sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and the diagnostic accuracy were calculated. The value of P <0.05 was considered statistically significant.

2.9 Ethical Considerations

The study protocol was approved by the Research Ethics Committee, College of Health and Medical Technologies, Al-Furat Al-Awsat Technical University, and the official permission for this study was taken from Al-Zahraa Teaching Hospital. In addition, the researchers obtained written consent from the participants after explaining the details and objectives of the study. The participants' information remained confidential, and it was used for research purposes only.

3. RESULTS

3.1 Demographic Characteristics

This case-control study had 100 pregnant women, 70 women diagnosed with gestational diabetes mellitus (GDM) (case group) and 30 healthy pregnant women (control group).

The mean maternal age was compared between the two groups. As shown in Table 1 and Figure 1, the mean maternal age was significantly lower in the GDM group (28.49 ± 6.89 years) than in the control group (31.90 ± 7.70 years), with a statistically significant difference (P = 0.041).

Table 1. Comparison of demographic and biochemical parameters

Variable	GDM (n=70)	Control (n=30)	P-value
Maternal age (years)	28.49 ± 6.89	31.90 ± 7.70	0.041
Hemoglobin (g/dL)	9.90 ± 1.20	10.35 ± 2.21	0.291
Random Blood Sugar (mg/dL)	263.34 ± 50.93	107.77 ± 13.56	<0.001

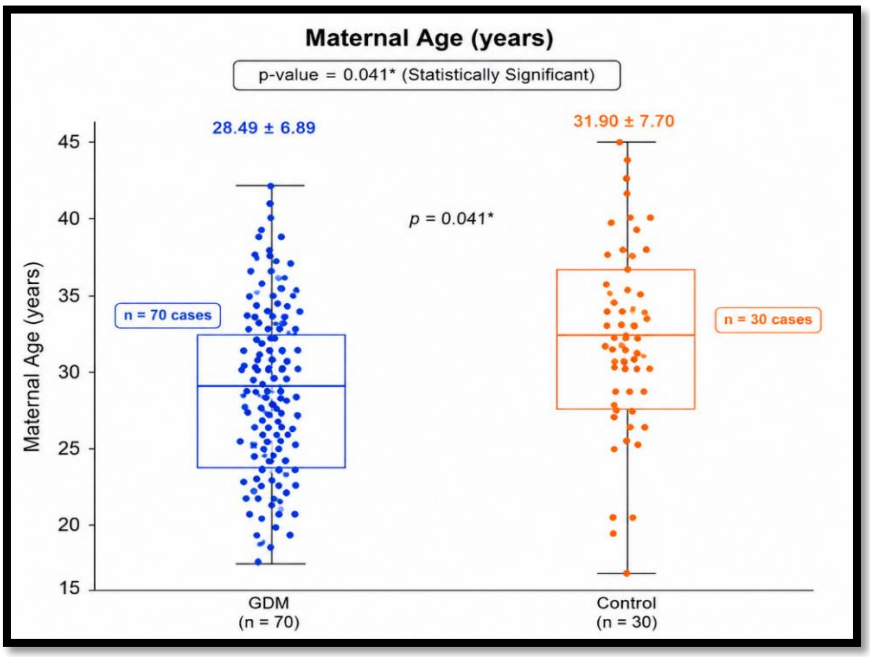

Figure 1. Comparison of maternal age between women with gestational diabetes mellitus (GDM) and healthy pregnant women. A statistically significant difference in maternal age was observed between the two groups (p = 0.041).

3.2 Comparison of Hemoglobin Levels

Hemoglobin concentration was lower in women with GDM (9.90 ± 1.20 g/dL) compared to healthy pregnant women (10.35 ± 2.21 g/dL) as in (Table 1, Figure 2). The difference between the two groups was not statistically significant (0.291), although hemoglobin levels were lower in women with GDM, hemoglobin concentration was not significantly in the present study.

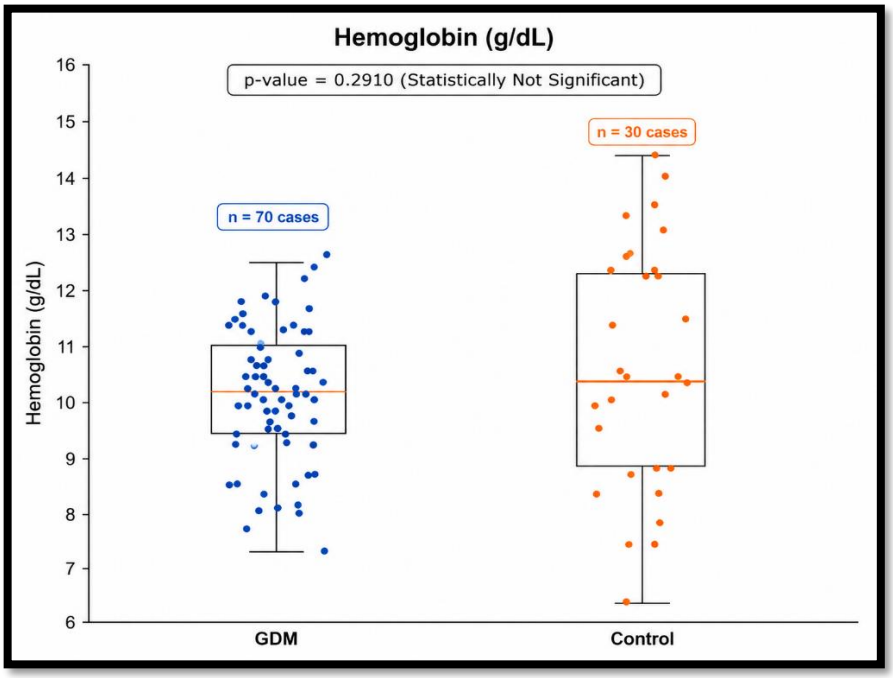

Figure 2. Comparison of hemoglobin levels between women with gestational diabetes mellitus (GDM) and healthy pregnant women. No statistically significant difference was observed between the two groups (p = 0.291).

3.3 Comparison of Random Blood Glucose Levels

The random blood glucose (RBG) levels were significantly higher in the GDM group (263.34 ± 50.93 mg/dl) than those in the control group (107.77±13.56 mg/dl) with a highly statistically significant difference (P < 0.001). It means that there is a great difference in blood sugar levels among pregnant women with gestational diabetes mellitus and those without the disease (Table 1, Figure 3).

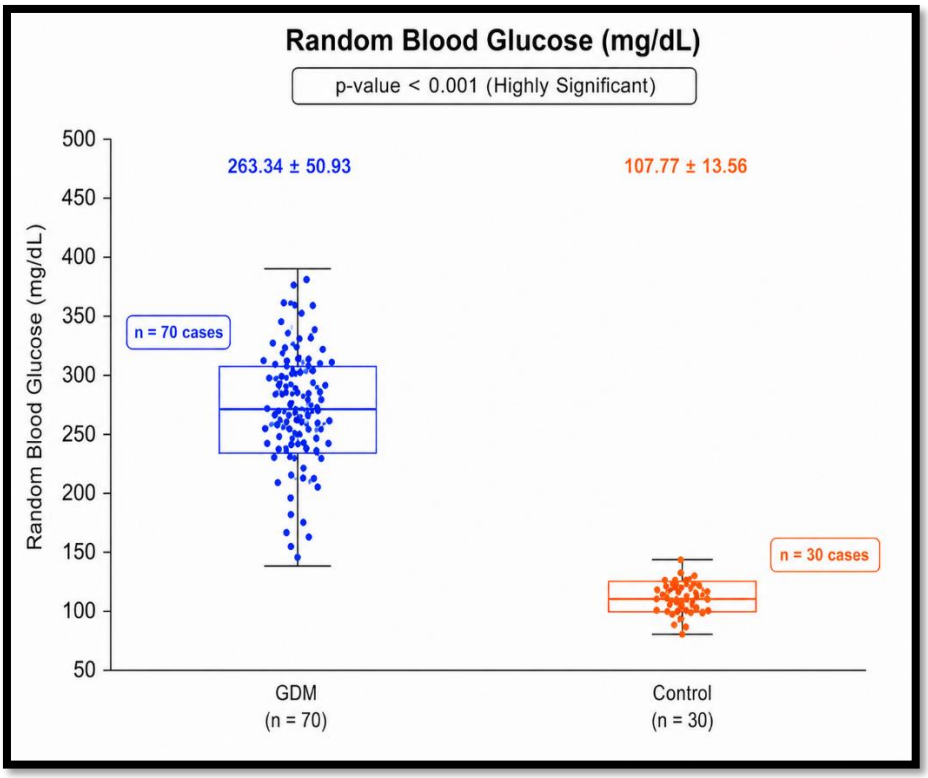

Figure 3. Comparison of random blood glucose levels between women with gestational diabetes mellitus (GDM) and healthy pregnant women. Random blood glucose levels were significantly higher in the GDM group than in the control group (P < 0.001).

3.4 Receiver Operating Characteristic (ROC) Analysis

A receiver operating characteristic (ROC) curve analysis was used to assess the diagnostic accuracy of random blood glucose (RBG) for the discrimination between women with gestational diabetes and healthy pregnant women. The diagnostic accuracy was found to be satisfactory with a large area under the ROC curve (AUC).

The optimal cut-off value was selected using the Youden index, which maximized true positive and true negative values. The obtained sensitivity, specificity, positive predictive value and negative predictive value are presented in Table 2 for the detection of women with GDM. The ROC curve for the current data is displayed in Fig. 4.

Table 2. Diagnostic Performance of Random Blood Glucose for Predicting Gestational Diabetes Mellitus.

Parameter	Value
Area Under the Curve (AUC)	1.000
Optimal Cut-off (mg/dL)	≥ 163
Sensitivity (%)	100.0
Specificity (%)	100.0

Table 2: Using the oral glucose tolerance test (OGTT) as the reference standard, random blood glucose (RBG) is used to diagnose gestational diabetes mellitus.

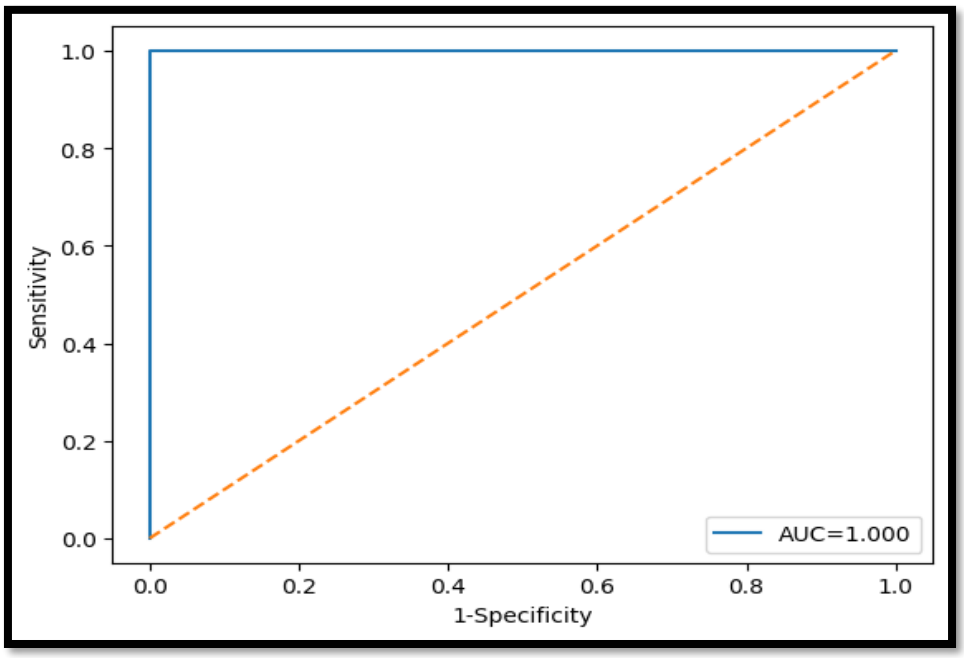

Figure 4. ROC Curve of Random Blood Glucose for Predicting Gestational Diabetes Mellitus.

The receiver operating characteristic (ROC) curve in Figure 4 shows how well random blood glucose (RBG) can diagnose gestational diabetes mellitus (GDM) using the oral glucose tolerance test (OGTT) as the reference standard. The area under the curve (AUC) represents RBG's total capacity for discrimination.

3.5 Correlation Analysis

Correlation analysis was used to assess the association between maternal age, hemoglobin levels and random blood glucose (RBS) levels among all participants (n = 100). Table 3 displays the correlation coefficient and associated P-value. Figure 5 displays the scatter plot that shows how the two variables are related.

Table 3. Correlation Analysis Between Maternal Age, Hemoglobin, and Random Blood Glucose Levels Among the Study Participants (n = 100).

Variables	Pearson's r	P-value
Maternal Age vs. Hemoglobin	0.367	< 0.001
Maternal Age vs. RBS	-0.138	0.171

Hemoglobin vs. RBS	-0.139	0.168

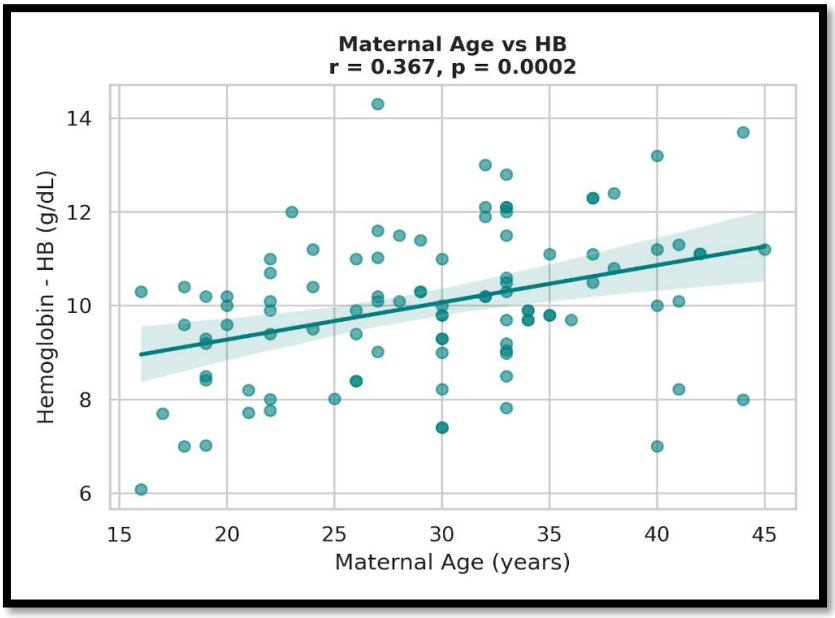

Figure 5. Correlation Between Maternal age and Hemoglobin.

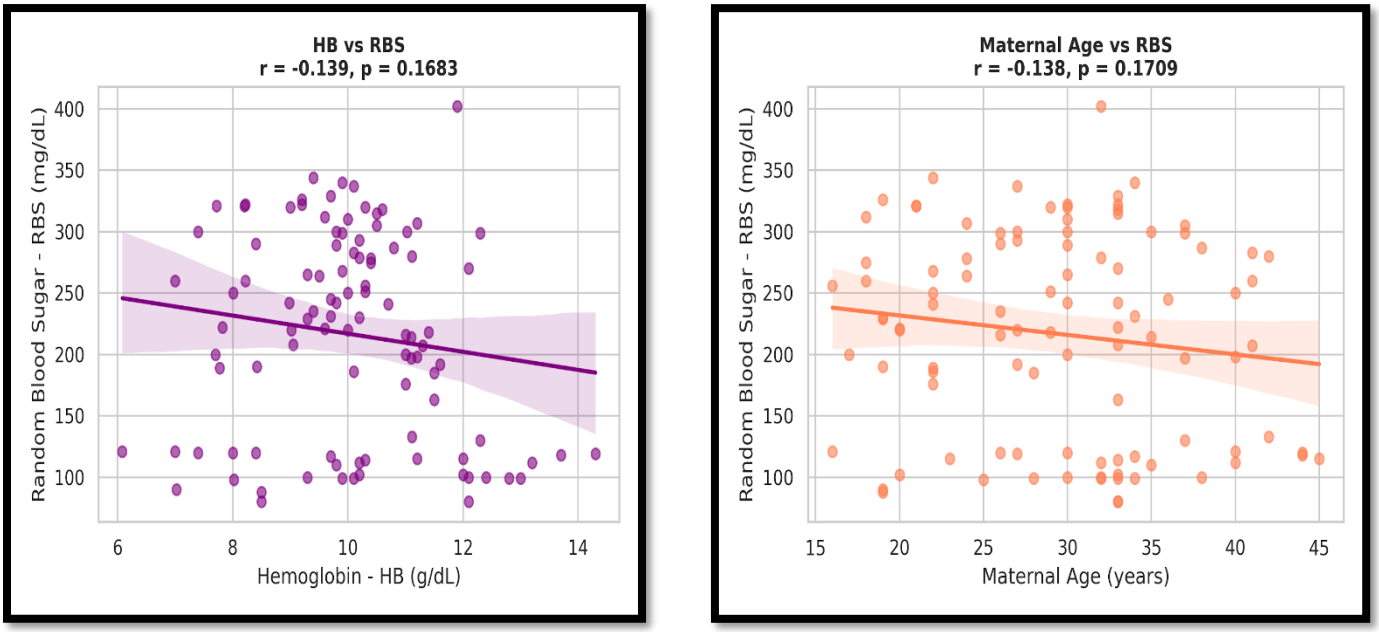

Figure 6. Correlation Between Maternal age and RBS, HB vs RBS.

The maternal age showed a moderate positive correlation with hemoglobin levels ($r = 0.367$, $p < 0.001$) as in Figure 5. However, no statistically significant correlation was observed between maternal age and random blood glucose levels ($r = -0.138$, $p = 0.171$) or between hemoglobin and random blood glucose levels ($r = -0.139$, $p = 0.168$) in Figure 6.

4. DISCUSSION

The present case-control study aimed to compare the maternal age, hemoglobin concentration and random blood glucose of pregnant women with gestational diabetes mellitus and their healthy pregnant in Najaf Province, Iraq. The study demonstrated statistically significant differences in maternal age and random blood glucose levels between the two groups, whereas the difference in hemoglobin concentration was not statistically significant.

Maternal age was significantly lower in women with GDM than in healthy pregnant controls. The average maternal age was 28.49 ± 6.89 years in the GDM group, whereas it was 31.90 ± 7.70 years in the control group (P = 0.041). This result contrasts with

the commonly reported relationship between advanced maternal age and a higher risk of GDM. A comprehensive systematic review and meta-analysis including over 120 million participants found that the risk of GDM generally rises with increasing maternal age [26]. Thus, the lower average age seen in women with GDM in this study should not be taken to mean that younger maternal age by itself increases the risk of GDM. Rather, this observation could be due to specific traits of the population studied or influenced by other unassessed factors—such as obesity, pre-pregnancy BMI, family history of diabetes, lifestyle habits, and underlying insulin resistance.

The difference in maternal age that was observed might also be affected by the uneven allocation of participants between the GDM group (n = 70) and the control group (n = 30). Existing guidelines advise standardized screening for GDM instead of depending solely on demographic factors, and stress screening during pregnancy based on established glucose-related criteria [27].

Compared to healthy pregnant controls, women with GDM exhibited a lower mean hemoglobin concentration (9.90 ± 1.20 vs. 10.35 ± 2.21 g/dL); however, this difference did not reach statistical significance (P = 0.291). This result indicates that, in the current study population, hemoglobin concentration alone was not significantly linked to GDM. The lack of a significant difference could be due to the intricate physiological changes during pregnancy, such as plasma-volume expansion, variations in iron status, nutritional factors, and shifts in red blood cell turnover.

This finding aligns with the idea that the link between maternal hemoglobin and GDM is intricate, possibly depending not just on the absolute hemoglobin level but also on fluctuations in hemoglobin during pregnancy and when it is measured. Sulhariza *et al.* found that shifts in maternal hemoglobin from early pregnancy to the second trimester were linked to GDM risk, suggesting that tracking hemoglobin over time may offer more insight than a single reading [28]. As a result, the lack of a statistically significant difference in hemoglobin levels observed in this study might be partly due to relying on a single measurement instead of tracking hemoglobin repeatedly over the course of pregnancy.

Recent prospective evidence has further shown that both maternal hemoglobin levels and their variations during pregnancy might be linked to GDM risk, indicating that the association depends on when the assessment occurs and the mother's iron status [29]. Therefore, a single hemoglobin reading may not sufficiently capture the intricate relationship between hematological status and abnormal glucose metabolism. Future research should thus assess repeated hemoglobin measurements along with more precise markers of iron status, such as serum ferritin, serum iron, and transferrin saturation.

Random blood glucose levels were notably and significantly elevated in women with GDM relative to healthy pregnant controls (263.34 ± 50.93 vs. 107.77 ± 13.56 mg/dL; P < 0.001). This marked difference aligns with the core disruption in glucose metabolism linked to GDM. In pregnancy, increasing insulin resistance arises as a normal physiological response; yet, when pancreatic β-cell compensation falls short, maternal hyperglycemia can develop.

This finding also supports the value of random glucose measurements as a marker of abnormal glycemic status. Meek et al. reported that random plasma glucose taken during pregnancy could help detect women at higher risk of later developing GDM, though it cannot substitute for standardized diagnostic testing [30]. In this study, all GDM cases were identified via OGTT; thus, the notable difference in random blood glucose reflects a biochemical difference between women with confirmed GDM and healthy pregnant controls, not a difference caused by the diagnostic classification itself.

While random blood glucose was the most powerful biochemical factor distinguishing the two groups in this study, it should not be viewed as a substitute for standardized diagnostic tests for GDM. The current ADA guidelines endorse glucose-based screening and diagnosis of GDM during pregnancy and acknowledge OGTT-based methods as well-established diagnostic approaches [27]. Therefore, random blood glucose can serve as an auxiliary biochemical marker of maternal glucose status during prenatal evaluation and monitoring, while standardized OGTT continues to be essential for diagnosing GDM.

Overall, this study showed that elevated maternal blood sugar was the key biochemical feature associated to GDM in the population studied Random blood glucose readings were notably higher in women with GDM, while hemoglobin levels were similar between the two groups. Maternal age also showed a significant difference, but the lower average age of women with GDM went against the typical pattern seen in major population studies.

The differences between the current results and those observed in other populations could be attributed to differences in maternal traits, nutritional condition, iron intake, gestational timing of lab tests, ethnicity, and the occurrence of additional metabolic risk factors. Thus, larger multi-center prospective investigations that include women from various Iraqi regions are advised to validate these outcomes and to assess the independent associations among maternal age, hemoglobin levels, and impaired glucose metabolism during pregnancy.

4.1 Strengths of the study

- All cases of GDM were diagnosed by OGTT.
- The laboratory parameters used are affordable and widely available in antenatal clinics.
- The study provides local data from Najaf Province, where published evidence remains limited.
- The study included 70 women with GDM and 30 healthy pregnant controls.

- The study evaluated gestational diabetes mellitus using both hematological and biochemical markers.

4.2 Limitations

- Single-center study.
- Serum ferritin, HbA1c, hematocrit, and inflammatory biomarkers were not evaluated.
- Important potential confounding variables, including pre-pregnancy BMI, parity, family history of diabetes, and iron supplementation, were not included in the analysis.

5. CONCLUSION

Finally, the regular hemoglobin assessment with glucose monitoring as a part of comprehensive antenatal care. Early identification and treatment of hyperglycemia and anemia might improve pregnancy outcomes and reduce the risk of several obstetrical and neonatal complications. However, the results of the study are limited by the relatively low sample size and single-center design. Therefore, there is a need for future multicenter studies, which should include a larger population of pregnant women and explore additional biochemical and hematological parameters to support the current findings and further understand the connection between anemia and gestational diabetes in Iraqi women. These findings may assist clinicians in improving the biochemical assessment of pregnant women at risk of gestational diabetes mellitus.

6. RECOMMENDATIONS

1- Gestational diabetes mellitus must be diagnosed by the oral glucose tolerance test in accordance with international clinical practice standards.
2- Routine estimation of hemoglobin should be carried out during pregnancy as a part of assessment for not only anemia but also gestational diabetes and metabolic status of mother.
3- Pregnant women with gestational diabetes mellitus (GDM) should undergo regular monitoring of glucose levels.
4- Pregnant women with abnormal hemoglobin should be evaluated and managed appropriately including assessment for potential iron deficiency.

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